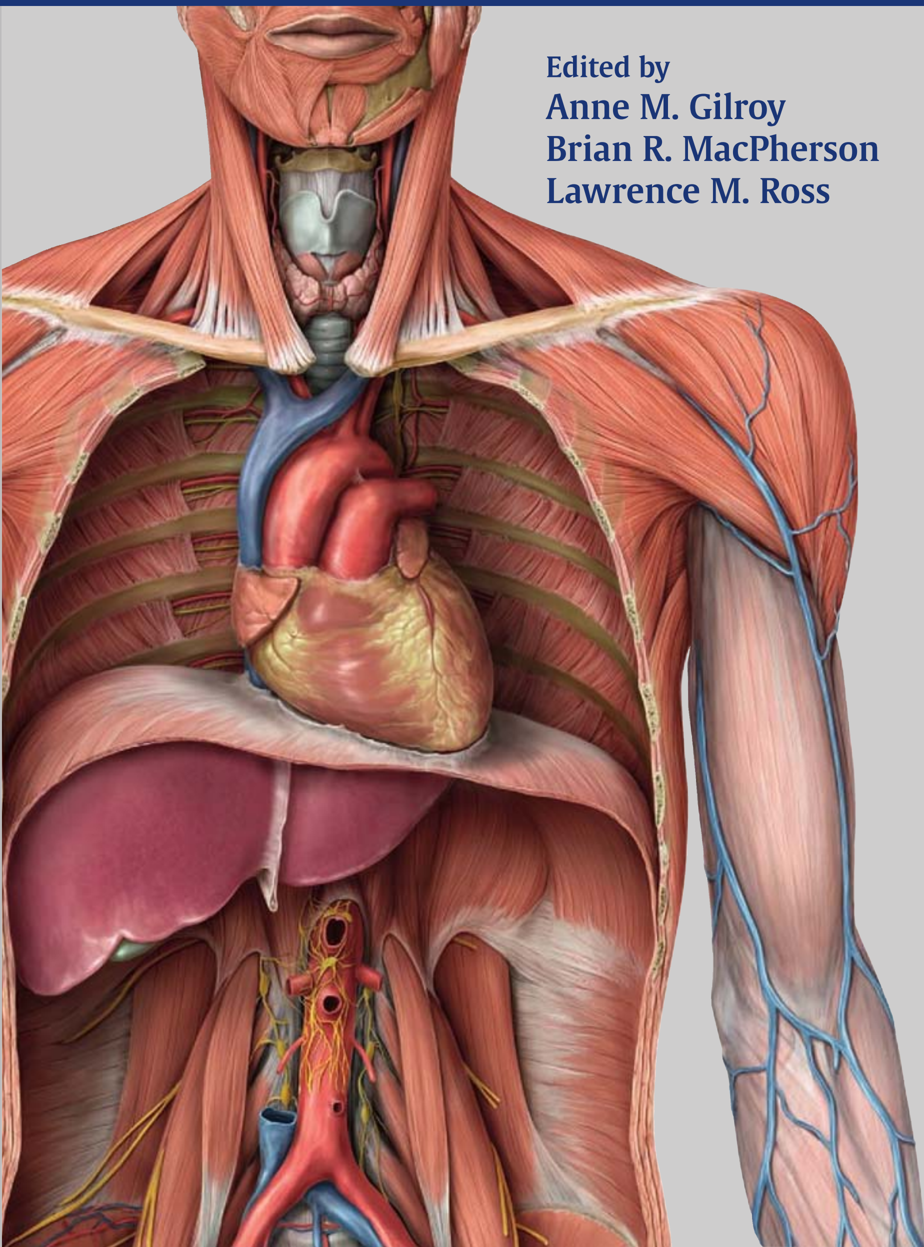
Atlas of Anatomy

Latin Nomenclature



Edited by
Anne M. Gilroy
Brian R. MacPherson
Lawrence M. Ross

Based on the work of
Michael Schuenke
Erik Schulte
Udo Schumacher

Consulting Editors
Jonas Broman
Anna Josephson

Illustrations by
Markus Voll
Karl Wesker

Thieme

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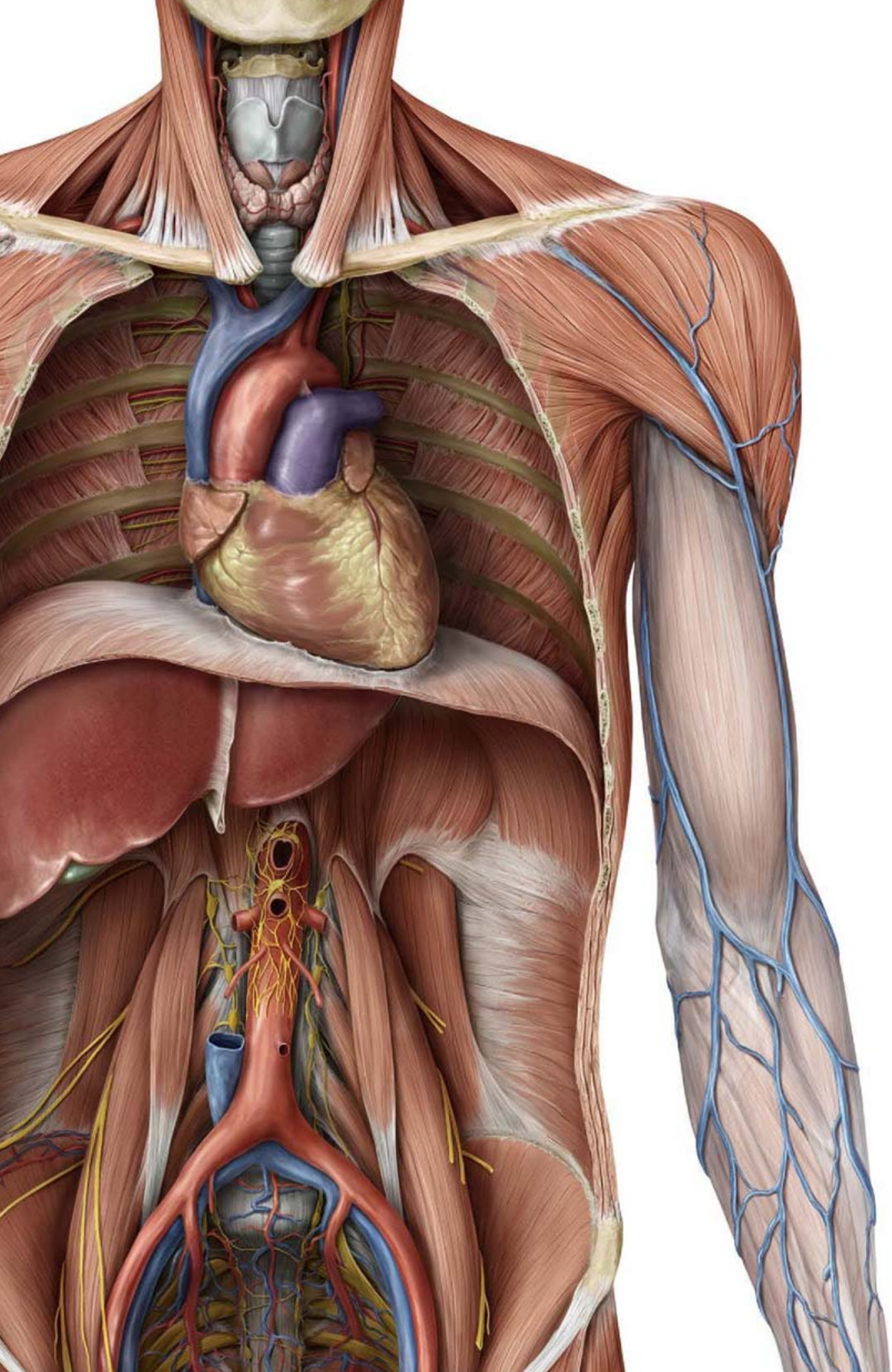

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Based on the work of Michael Schuenke, MD, PhD,
Erik Schulte, MD, and Udo Schumacher, MD

Anne M. Gilroy, MA
Dept. of Cell Biology and Dept. of Surgery
University of Massachusetts Medical School
55 Lake Avenue North
Worcester, MA 01655-0333

Brian R. MacPherson, PhD
Department of Anatomy and Neurobiology
MN225 Chandler Medical Center
University of Kentucky College of Medicine
Lexington, KY 40536-0298

Lawrence M. Ross, MD, PhD
Department of Neurobiology and Anatomy
University of Texas Medical School at Houston
6431 Fannin, Suite 7.046
Houston, TX 77030

Michael Schuenke, MD, PhD
Institute of Anatomy
Christian Albrecht University Kiel
Olshausenstrasse 40
D-24098 Kiel

Erik Schulte, MD
Department of Anatomy and Cell Biology
Johannes Gutenberg University
Saarstrasse 19-21
D-55099 Mainz

Udo Schumacher, MD, FRCPath, CBiol, FIBiol, DSc
Institute of Anatomy II: Experimental Morphology
Center for Experimental Medicine
University Medical Center Hamburg-Eppendorf
Martinistrasse 52
D-20246 Hamburg

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Developmental Editor: Bridget N. Queenan
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Consulting Editors
Jonas Broman, PhD
Anna Josephson, MD, PhD
Department of Neuroscience
Karolinska Institutet
S-17177 Stockholm

Illustrators
Markus Voll
Karl Wesker

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Dedication

To my father, Francis Gilroy, whose dedication to medicine has been a greater inspiration to me than he has ever realized; to my students who lovingly tolerate, and sometimes share, my passion for human anatomy; and most of all to my sons, Colin & Bryan, whose love and support I treasure beyond all else.

To my friend and mentor, Dr. Ken McFadden of the Division of Anatomy at the University of Alberta, who ensured I received the training in gross anatomy instruction required to be successful, and to the thousands of professional students who I have taught over the past 30 years honing these skills. However, none of the success I've enjoyed during my time in academia would have been possible without the constant support, participation and encouragement of my wife, Cynthia Long.

To my wife, Irene; to the children, Chip, Jennifer, Jocelyn & Barry, Tricia, Scott, Katie & Snapper, and Trey; and to my students who have taught me so well.

Foreword

This Atlas of Anatomy is, in my opinion, the finest single volume atlas of human anatomy that has ever been created. Two factors make it so: the images and the way they have been organized.

The artists, Markus Voll and Karl Wesker, have created a new standard of excellence in anatomical art. Their graceful use of transparency and their sensitive representation of light and shadow give the reader an accurate three-dimensional understanding of every structure.

The authors have organized the images so that they give just the flow of information a student needs to build up a clear mental image of the human body. Each two-page spread is a self-contained lesson that unobtrusively shows the hand of an experienced and thoughtful teacher. I wish I could have held this book in my hands when I was a student; I envy any student who does so now.

Robert B. Acland
Louisville, KY   March 2008

Acknowledgments

We would like to thank the authors of the original award-winning Anatomy Series Michael Schuenke, Erik Schulte, and Udo Schumacher for their work over the course of many years.

We cordially thank the members of the Advisory Board for their contributions.

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- Kelly Wright (Class of 2010)
  Wayne State University School of Medicine
  Detroit, Michigan

We gratefully acknowledge the contribution of the student translators from the Karolinska Institute in Stockholm, Sweden: Christoffer Brynte, Mårten Fällman, Jacob Lannerbro, and Hannah Sjöstedt.

Preface

Each of us was amazed and impressed with the extraordinary detail, accuracy, and beauty of the material that was created for the Thieme Atlas of Anatomy by authors Michael Schuenke, Erik Schulte, and Udo Schumacher and artists Markus Voll and Karl Wesker. We felt these atlases and their pedagogical concepts were one of the most significant additions to anatomical education in the past 50 years. It was our intent to use this exceptional material as the cornerstone of our effort to create a concise single volume Atlas of Anatomy for the curious and eager health science student.

Our challenge was first to select from this extensive collection those images that are most instructive and illustrative of current dissection approaches. Along the way, however, we realized that creating a single volume atlas was much more than choosing images: each image had to convey a significant amount of detail while the appeal and labeling needed to be clean and soothing to the eye. Therefore, hundreds of illustrations were drawn new or modified to fit the approach of this new atlas. In addition, key schematic diagrams and simplified summary-form tables were added wherever needed. Dozens of applicable radiographic images and important clinical correlates have been added where appropriate. Additionally, surface anatomy illustrations are accompanied by questions designed to direct the student's attention to anatomic detail that is most relevant in conducting the physical exam. Elements from each of these features are arranged in a regional format to facilitate common dissection approaches. Within each region the various components are examined systemically, followed by topographical images to tie the systems within the region together. In all of this, a clinical perspective on the anatomical structures is taken. The unique two facing pages "spread" format focuses the user to the area/topic being explored.

We hope these efforts, the results of close to 100 combined years of experience teaching the discipline of anatomy to bright, enthusiastic students, has resulted in a comprehensive, easy-to-use resource and reference.

We would like to thank our colleagues at Thieme Publishers who so professionally facilitated this effort. We cannot thank enough, Cathrin E. Schulz, MD, Editorial Director Educational Products, who so graciously reminded us of deadlines, while always being available to troubleshoot problems. More importantly, she encouraged, helped, and complimented our efforts.

We also wish to extend very special thanks and appreciation to Bridget Queenan, Developmental Editor, who edited and developed the manuscript with an outstanding talent for visualization and intuitive flow of information. We are very grateful to her for catching many details along the way while always patiently responding to requests for artwork and labeling changes.

Cordial thanks to Elsie Starbecker, Senior Production Editor, who with great care and speed produced this atlas with its over 2,200 illustrations. Finally thanks to Rebecca McTavish, Developmental Editor, for joining the team in the correction phase. Their hard work has made the Atlas of Anatomy a reality.

Anne M. Gilroy
Brian R. MacPherson
Lawrence M. Ross

March 2008,
Worcester, MA, Lexington, KY, and Houston, TX

To access additional material or resources available with this e-book, please visit http://www.thieme.com/bonuscontent. After completing a short form to verify your e-book purchase, you will be provided with the instructions and access codes necessary to retrieve any bonus content.

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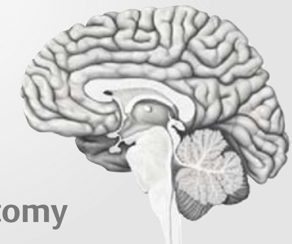
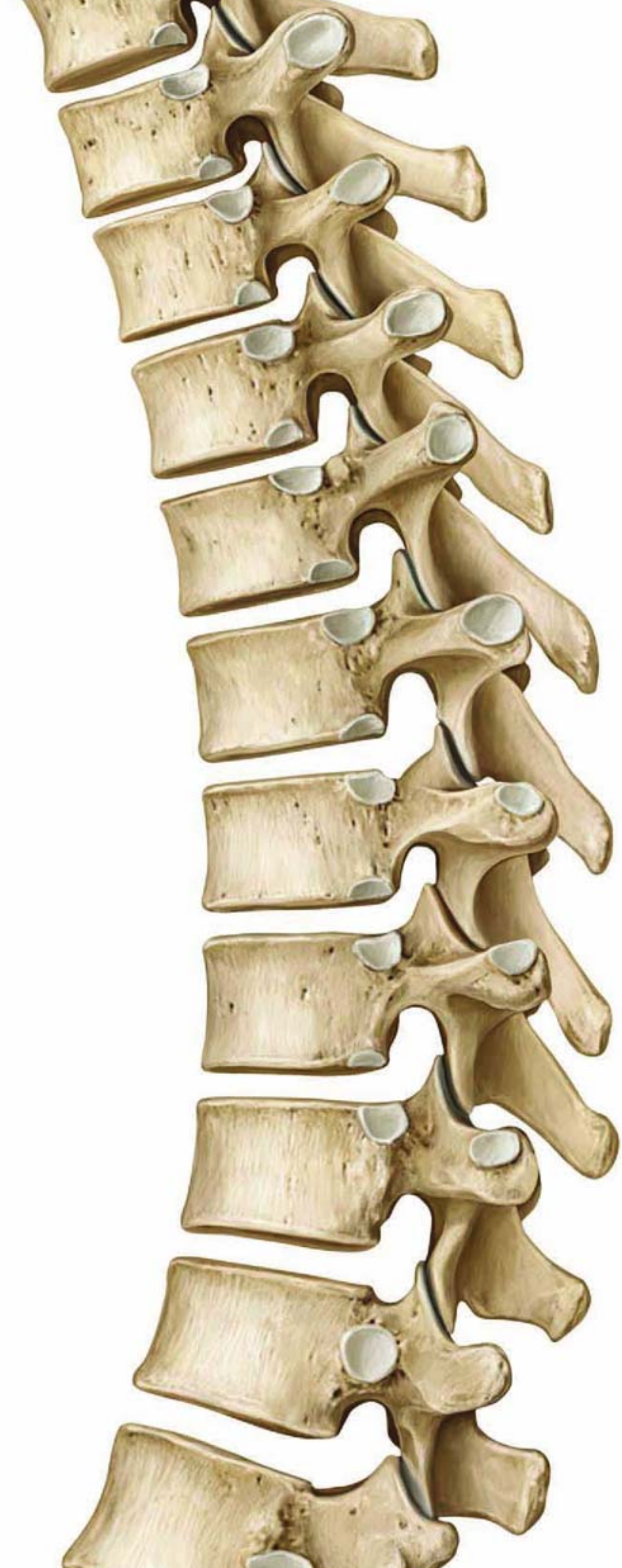


Neuroanatomy

Appendix



Back

1 Bones, Ligaments & Joints

2 Muscles

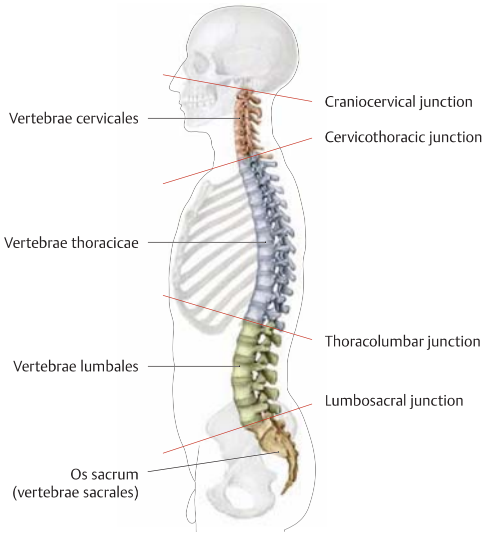
3 Neurovasculature

4 Surface Anatomy

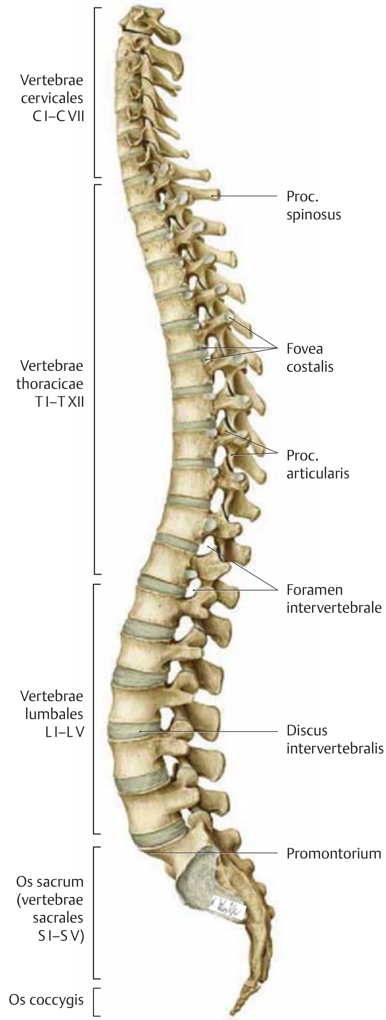
Columna Vertebralis: Overview

Columna vertebralis (spine) is divided into four regions: the cervical, thoracic, lumbar, and sacral spines. Both the cervical and lumbar spines demonstrate lordosis (inward curvature); the thoracic and sacral spines demonstrate kyphosis (outward curvature).

Fig. 1.1 **Columna vertebralis**
Left lateral view.



A Regions of the spine.



B Bony vertebral column.

Clinical

Spinal development
The characteristic curvatures of the adult spine appear over the course of postnatal development, being only partially present in a newborn. The newborn has a "kyphotic" spinal curvature (**A**); lumbar lordosis develops later and becomes stable at puberty (**C**).

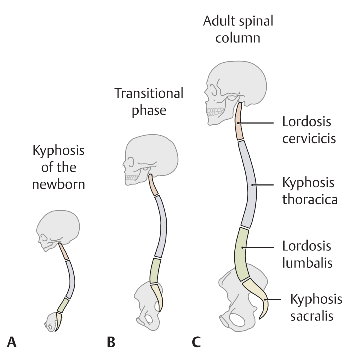
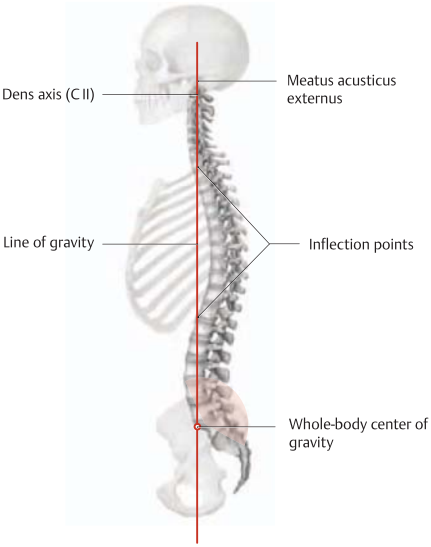
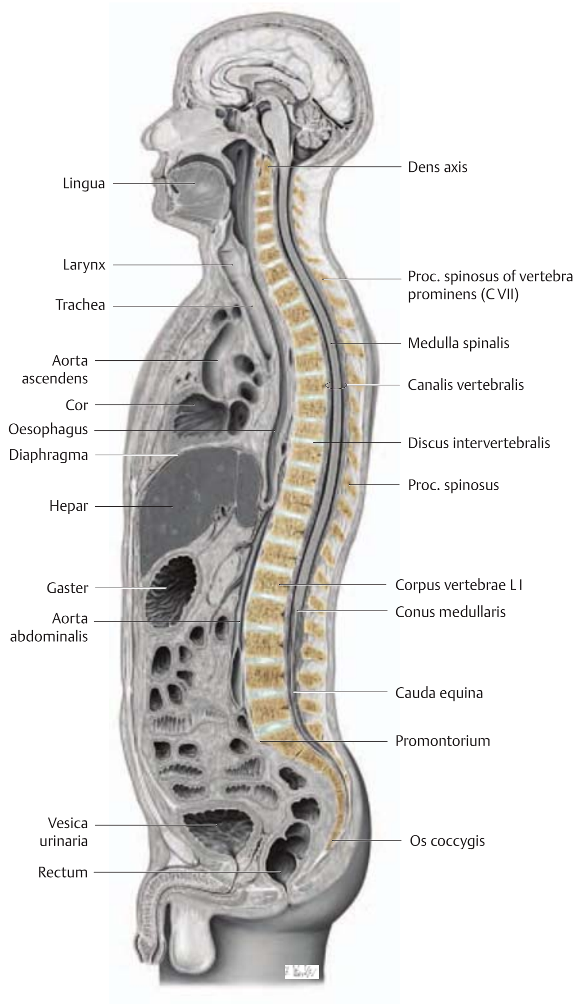


***Fig. 1.2* Normal anatomical position of the spine**
Left lateral view.



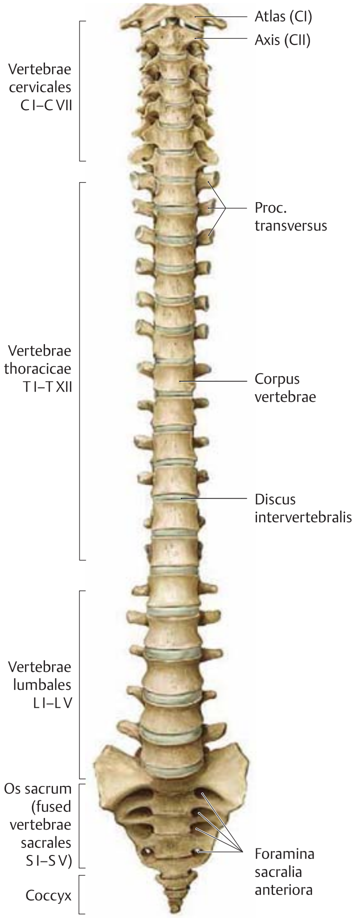
A Line of gravity. The line of gravity passes through certain anatomical landmarks, including the inflection points at the cervicothoracic and thoracolumbar junctions. It continues through the center of gravity (anterior to the sacral promontory) before passing through the hip joint, knee, and ankle.



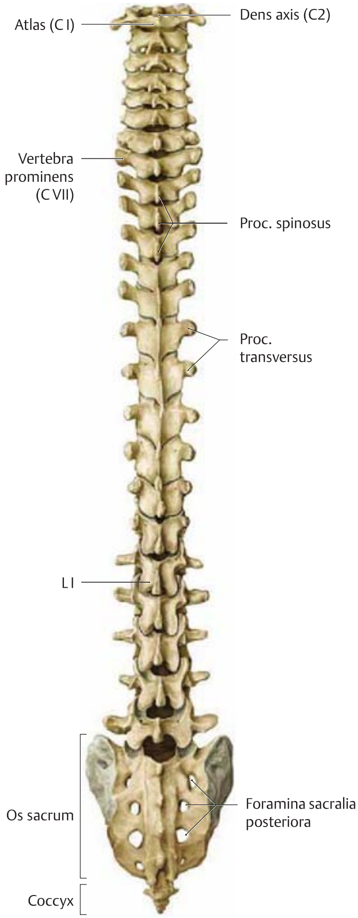
B Midsagittal section through an adult male.

Columna Vertebrales: Elements

Fig. 1.3 **Bones of columna vertebrales**



A Anterior view.



B Posterior view.

Fig. 1.4 **Palpable processus spinosus as landmarks**

Posterior view. The easily palpated processus spinosus provide important landmarks during physical examination.

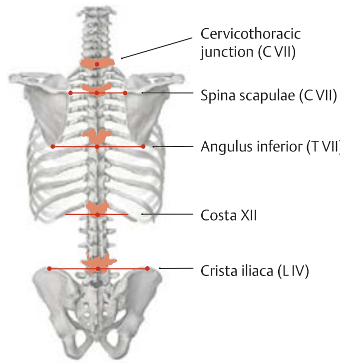


Fig. 1.5 **Structural elements of a vertebra**

Left posterosuperior view. With the exception of the atlas (C I) and axis (C II), all vertebrae consist of the same structural elements.

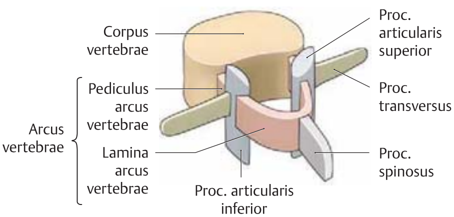
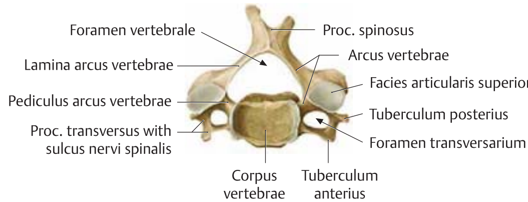
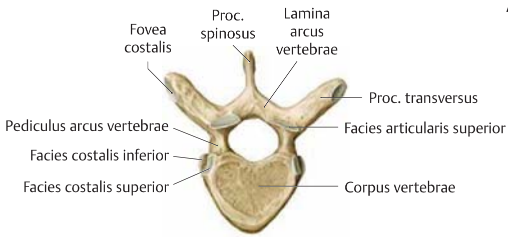


Fig. 1.6 **Typical vertebrae**

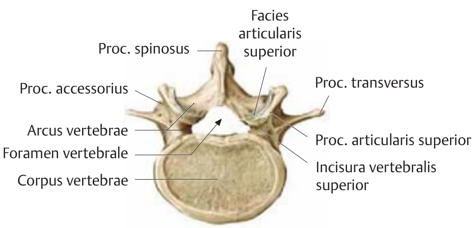
Superior view.



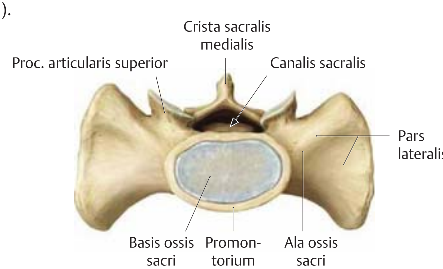
A Vertebra cervicalis (C IV).



B Vertebra thoracalis (T VI).



C Vertebra lumbalis (L IV).



D Os sacrum.

Table 1.1 **Structural elements of vertebrae**

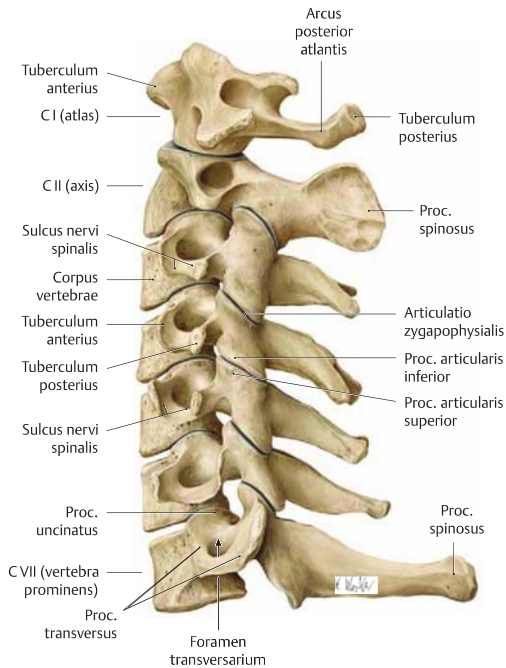
Vertebrae	Body	Vertebral foramen	Transverse processes	Articular processes	Spinous process
Vertebrae cervicales C III*–C VII	Small (kidney-shaped)	Large (triangular)	Small (may be absent in C VII); tuberculum anterius and posterius enclose foramen transversum	Superoposteriorly and inferoanteriorly; oblique facets: most nearly horizontal	Short (C III–C V); bifid (C III–C VI); long (CVII)
Vertebrae thoracicae T I–T XII	Medium (heart-shaped); includes costal facets	Small (circular)	Large and strong; length decreases T I–T XII; costal facets (T I–T X)	Posteriorly (slightly laterally) and anteriorly (slightly medially); facets in coronal plane	Long, sloping postero-inferiorly; tip extends to level of vertebral body below
Vertebrae lumbales L I–L V	Large (kidney-shaped)	Medium (triangular)	Long and slender; proc. accessorius on posterior surface	Posteromedially (or medially) and anterolaterally (or laterally); facets nearly in sagittal plane; proc. mammilaris on posterior surface of each processus articularis superior	Short and broad
Vertebrae sacrales (os sacrum) S I–S V (fused)	Decreases from base to apex	Canalis sacralis	Fused to rudimentary rib (ribs, see pp. 44–47)	Superoposteriorly (SI) superior surface of lateral sacrumauricular surface	Crista sacralis mediana

*C I (atlas) and C II (axis) are considered atypical (see pp. 6–7).

Vertebrae Cervicales

The seven vertebrae of the cervical spine differ most conspicuously from the common vertebral morphology. They are specialized to bear the weight of the head and allow the neck to move in all directions. C I and C II are known as the atlas and axis, respectively. C VII is called the vertebra prominens for its long, palpable spinous process.

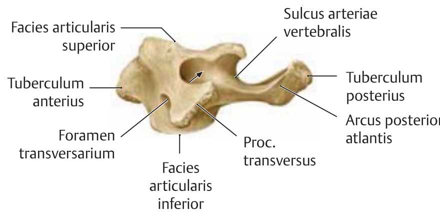
Fig. 1.7 **Cervical spine**
Left lateral view.



A Bones of the cervical spine, left lateral view.

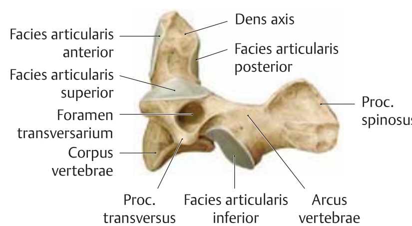
B Radiograph of the cervical spine, left lateral view.

Fig. 1.8 **Atlas (C I)**



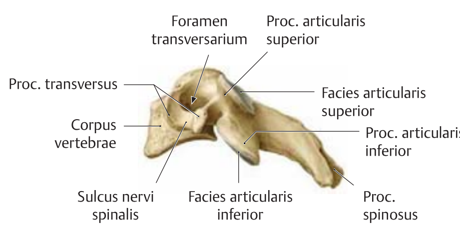
A Left lateral view.

Fig. 1.9 **Axis (C II)**



A Left lateral view.

Fig. 1.10 **Typical cervical vertebra (C IV)**

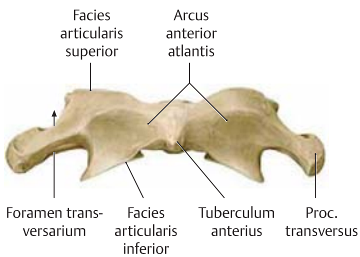


A Left lateral view.

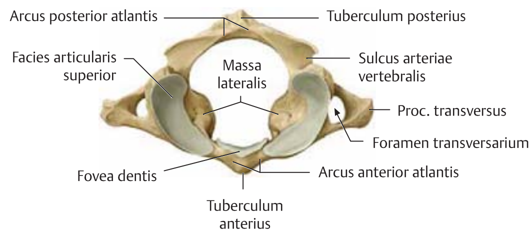
Clinical

Injuries in the cervical spine
The cervical spine is prone to hyperextension injuries, such as “whiplash,” which can occur when the head extends back much farther than it normally would. The most common injuries of the cervical spine are fractures of the dens of the axis, traumatic spondylolisthesis (ventral slippage of a vertebral body), and atlas fractures. Patient prognosis is largely dependent on the spinal level of the injuries (see p. 600).

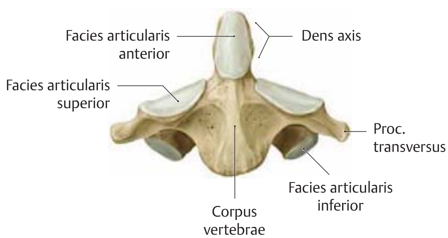
This patient hit the dashboard of his car while not wearing a seat belt. The resulting hyperextension caused the traumatic spondylolisthesis of C II (axis) with fracture of arcus vertebrae of C II, as well as tearing of the ligaments between C II and C III. This injury is often referred to as “hangman’s fracture.”



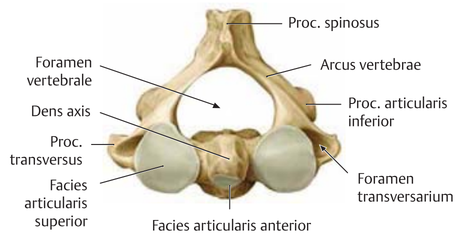
B Anterior view.



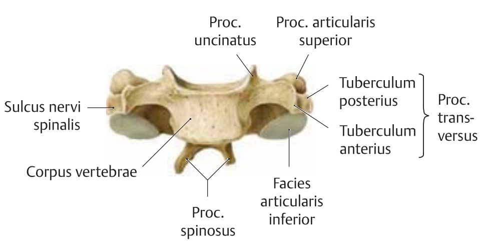
C Superior view.



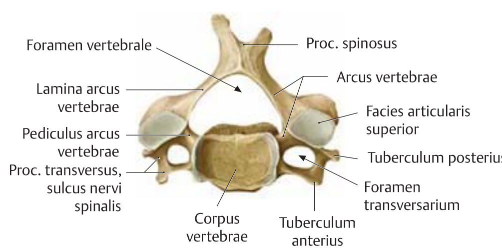
B Anterior view.



C Superior view.



B Anterior view.



C Superior view.

Vertebrae Thoracicae and Lumbales

***Fig. 1.11* Thoracic spine**
Left lateral view.

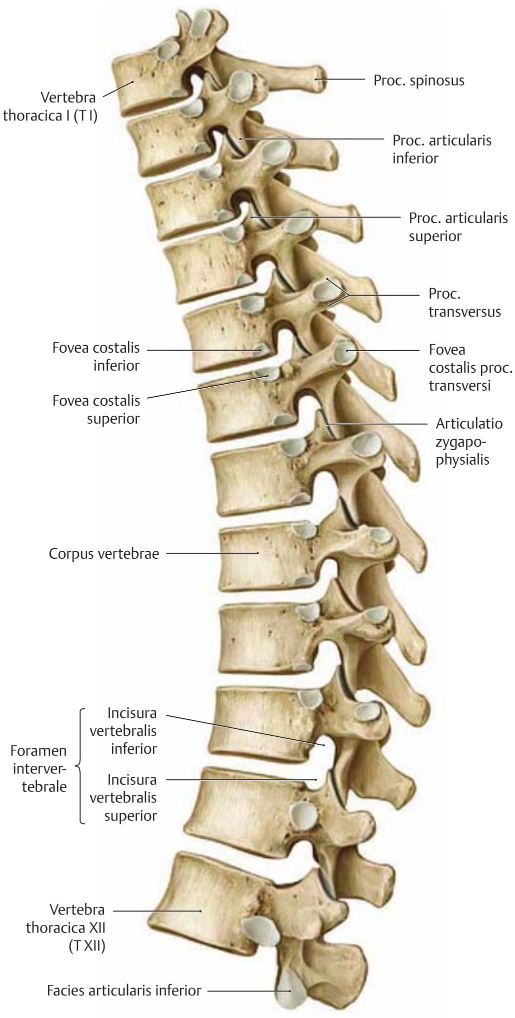
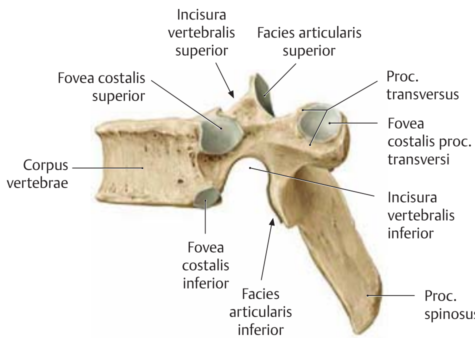
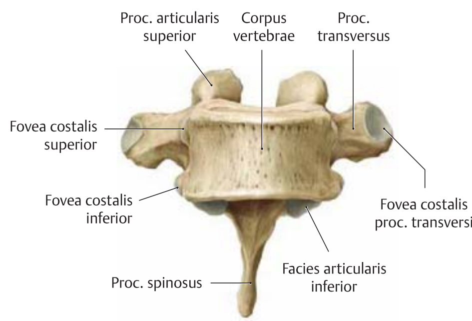


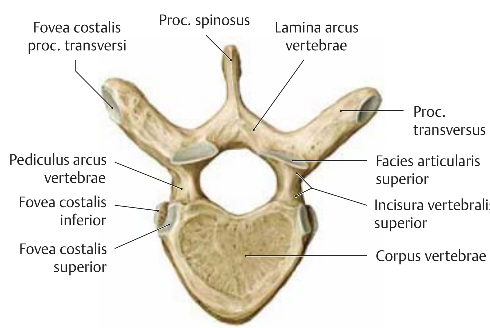
***Fig. 1.12* Typical vertebra thoracalis (T VI)**



A Left lateral view.



B Anterior view.



C Superior view.

Fig. 1.13 **Lumbar spine**
Left lateral view.

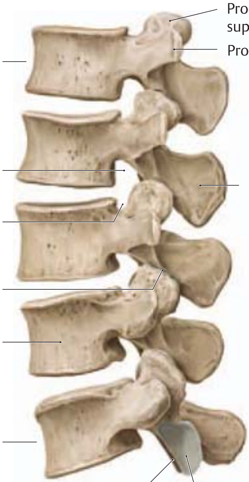
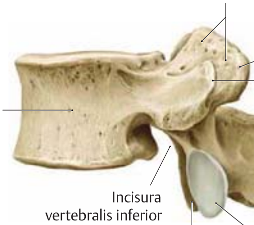
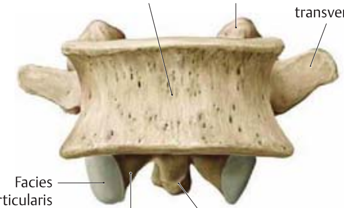


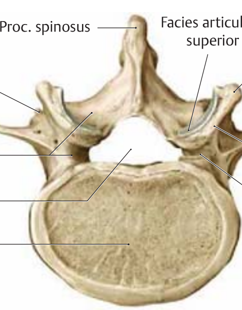
Fig. 1.14 **Typical vertebra lumbalis (L IV)**



A Left lateral view.



B Anterior view.



C Superior view.

Clinical

Osteoporosis

The spine is the structure most affected by degenerative diseases of the skeleton, such as arthrosis and osteoporosis. In osteoporosis, more bone material gets reabsorbed than built up, resulting in a loss of bone mass. Symptoms include compression fractures and resulting back pain.

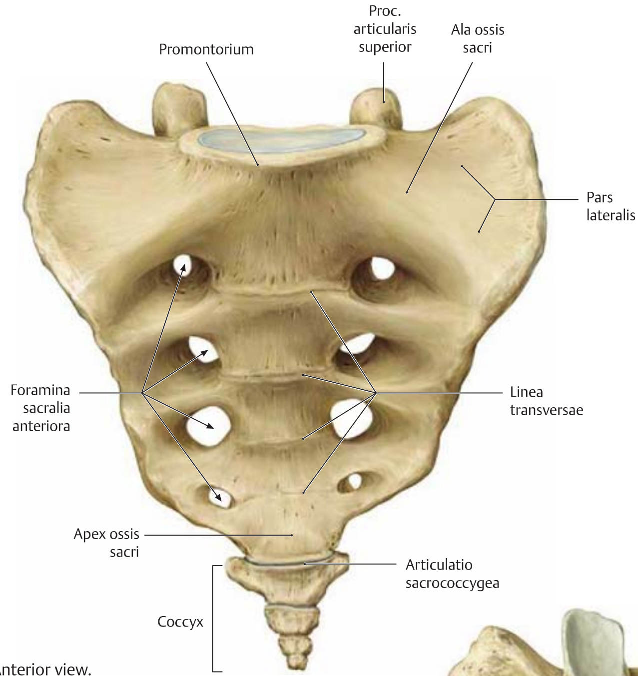
A Radiograph of a normal lumbar spine, left lateral view.

B Radiograph of an osteoporotic spine. Corpus vertebrae are decreased in density, and the internal trabecular structure is coarse. Lower and upper end plates are fractured.

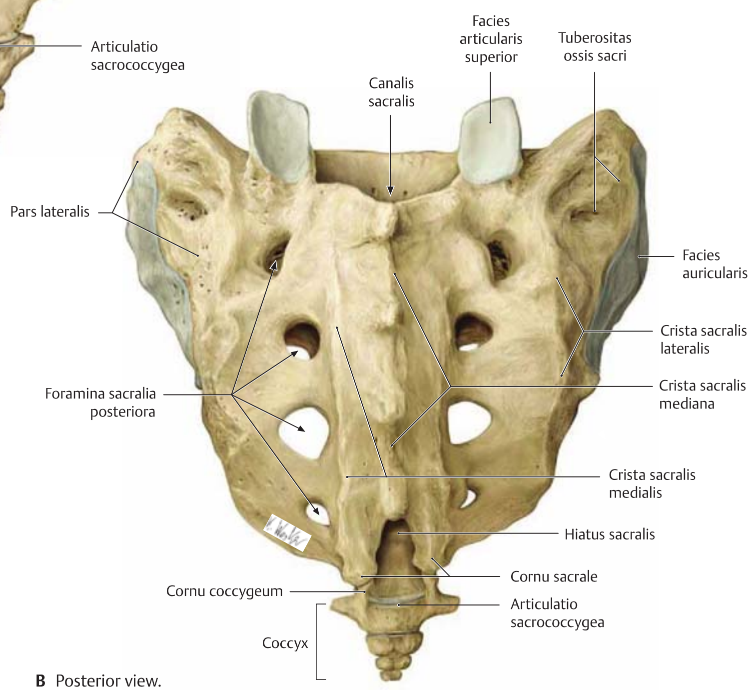
Os Sacrum and Os Coccygis

The sacrum is formed from five postnatally fused sacral vertebrae. The base of the sacrum articulates with the fifth lumbar vertebra (L V), and the apex articulates with the coccyx, a series of three or four rudimentary vertebrae.

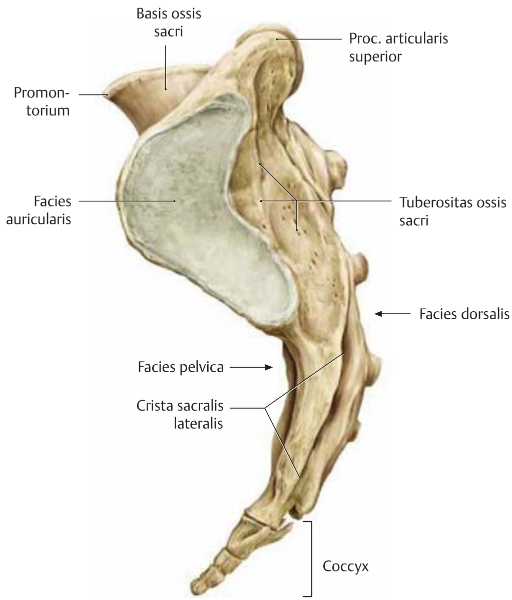
Fig. 1.15 **Os sacrum and os coccygis**



A Anterior view.



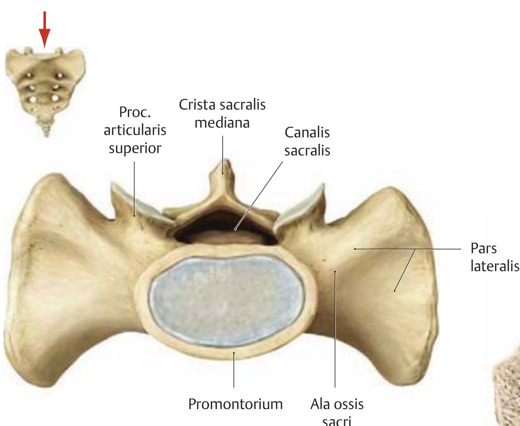
B Posterior view.



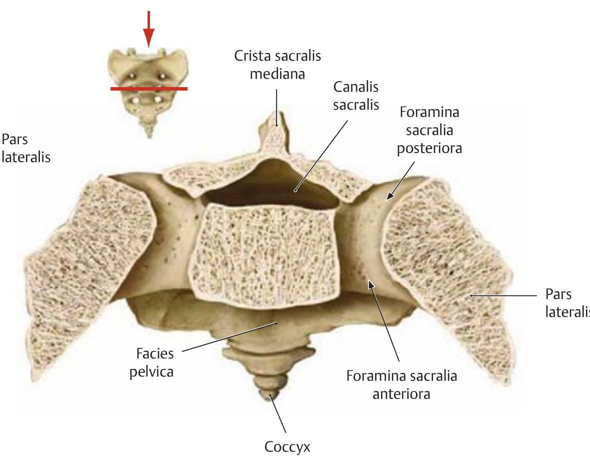
C Left lateral view.

D Radiograph of sacrum, anteroposterior view.

Fig. 1.16 **Os sacrum**
Superior view.



A Basis ossi sacri, superior view.



B Transverse section through second sacral vertebra demonstrating foramina sacralia anteriora and posteriora, superior view.

Discus Intervertebralis

Fig. 1.17 **Discus intervertebralis in columna vertebralis**
Sagittal section of T XI–T XII, left lateral view. The discus intervertebralis occupy the spaces between vertebrae (intervertebral joints, see p. 14).

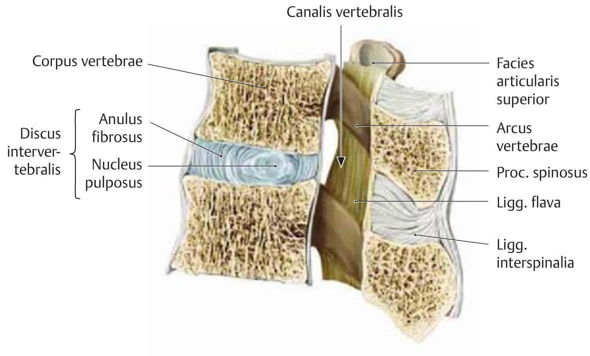


Fig. 1.18 **Structure of discus intervertebralis**
Anterosuperior view with the anterior half of the disk and the right half of the end plate removed. The intervertebral disk consists of an external fibrous ring (anulus fibrosus) and a gelatinous core (nucleus pulposus).

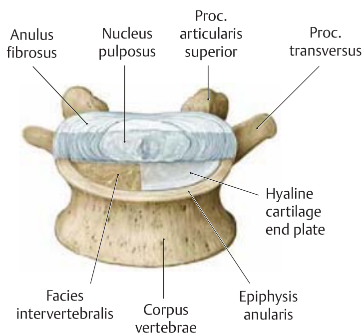


Fig. 1.19 **Relation of discus intervertebralis to canalis vertebralis**
Fourth lumbar vertebra, superior view.

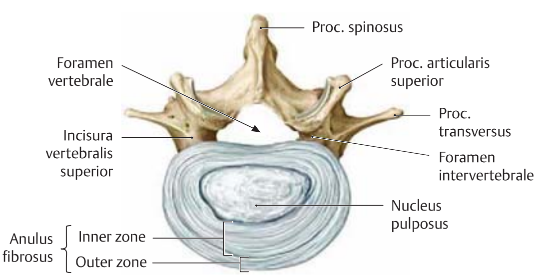
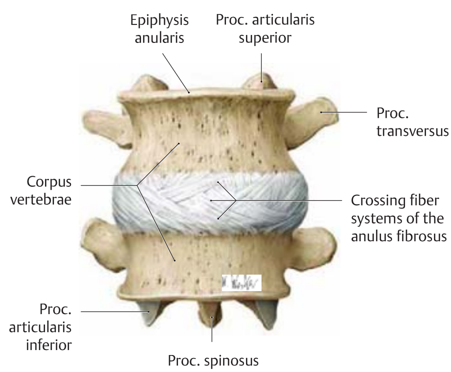
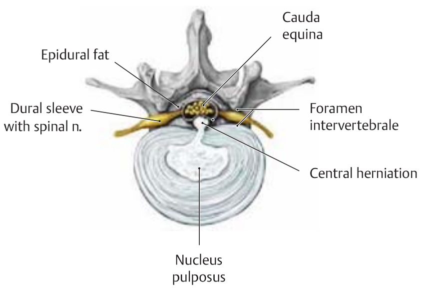


Fig. 1.20 **Outer zone of the anulus fibrosus**
Anterior view of L III–L IV with intervertebral disk.

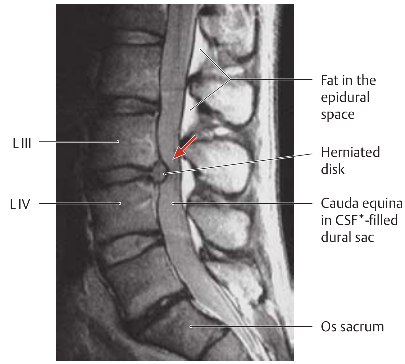


Clinical

Disk herniation, hernia disci intervertebralis, in the lumbar spine
As the stress resistance of the anulus fibrosus declines with age, the tissue of the nucleus pulposus may protrude through weak spots under loading. If the fibrous ring of the anulus ruptures completely, the herniated material may compress the contents of the intervertebral foramen (nerve roots and blood vessels). These patients often suffer from severe local back pain. Pain is also felt in the associated dermatome (see p. 600). When the motor part of the spinal nerve is affected, the muscles served by that spinal nerve will show weakening. It is an important diagnostic step to test the muscles innervated by a nerve from a certain spinal segment, as well as the sensitivity in the specific dermatome. Example: The first sacral nerve root (S1) innervates the gastrocnemius and soleus muscles; thus, standing or walking on toes can be affected (see p. 398).

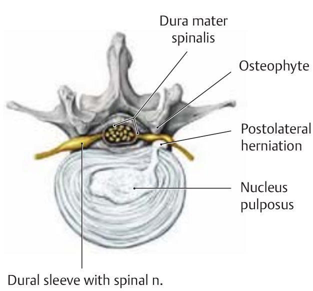


A Superior view.

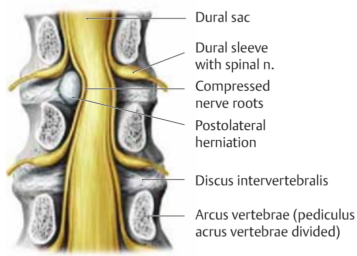


B Midsagittal T2-weighted MRI (magnetic resonance image).

Posterior herniation (A, B) In the MRI, a conspicuously herniated disk at the level of L III–L IV protrudes posteriorly (transligamentous herniation). The dural sac is deeply indented at that level. *CSF (cerebrospinal fluid).



C Superior view.



D Posterior view, arcus vertebrae removed.

Posterolateral herniation (C, D) A posterolateral herniation may compress the spinal nerve as it passes through the intervertebral foramen. If more medially positioned, the herniation may spare the nerve at that level, but impact nerves at inferior levels.

Articulationes Columnae Vertebralis: Overview

Table 1.2	Joints of the vertebral column	
Craniovertebral joints		
①	Articulationes atlantooccipitales	Occiput–C I
②	Articulationes atlantoaxiales	C I–C II
Joints of the vertebral bodies		
③	Articulationes uncovertebrales	C III–C VII
④	Articulationes intervertebrales	C I–S I
Joints of the vertebral arch		
⑤	Articulationes zygapophyseales	C I–S I

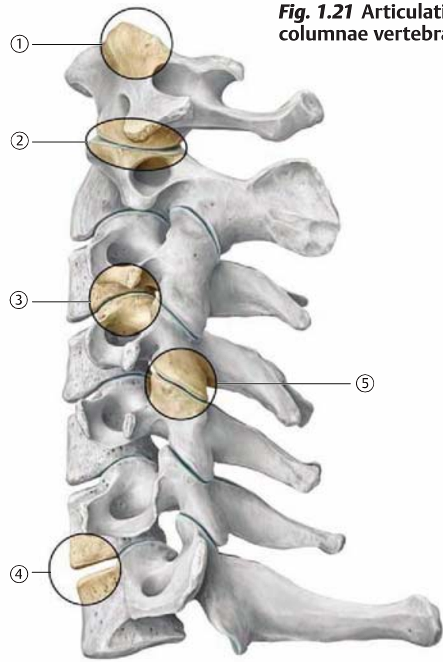
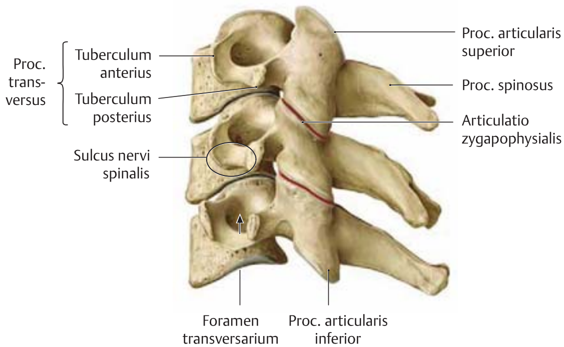


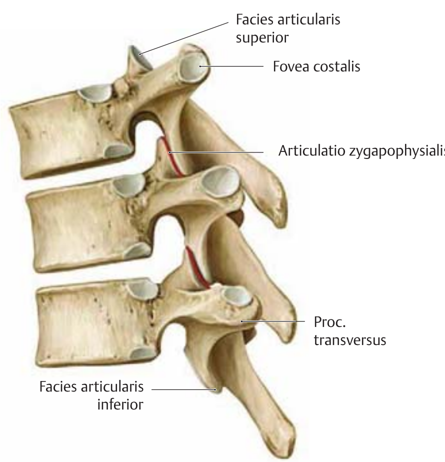
Fig. 1.21 **Articulationes columnae vertebralis**

Fig. 1.22 **Articulationes zygapophysiales (intervertebral facet)**

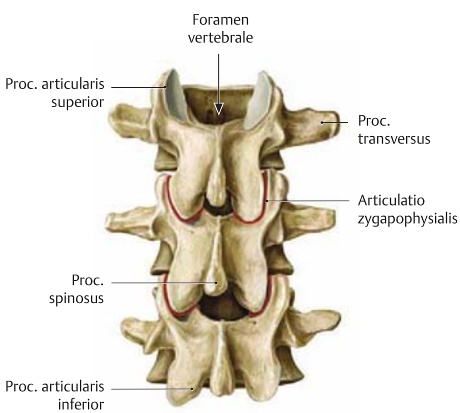
The orientation of articulationes zygapophysiales differs between the spinal regions, influencing the degree and direction of movement.



A Cervical region, left lateral view. Articulationes zygapophysiales lie 45 degrees from the horizontal.



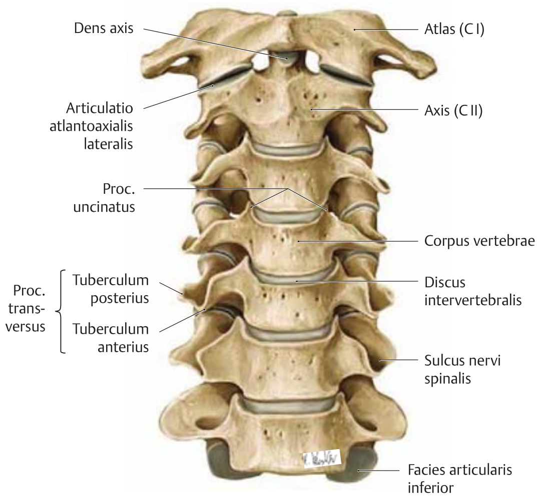
B Thoracic region, left lateral view. The joints lie in the coronal plane.



C Lumbar region, posterior view. The joints lie in the sagittal plane.

Fig. 1.23 **Articulationes uncovertebrales**

Anterior view. Articulationes uncovertebrales form during childhood between processus uncinatus of C III–C VI and corpus vertebrae immediately superior. The joints may result from fissures in the cartilage of the disks that assume an articular character. If the fissures become complete tears, the risk of pulposus herniation is increased (see p. 13).



A Articulationes uncovertebrales in the cervical spine of an 18-year-old man, anterior view.

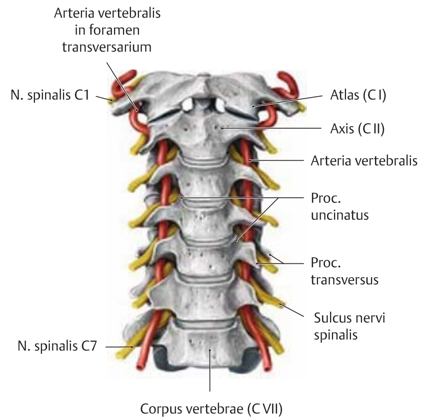
B Articulationes uncovertebrales (enlarged), anterior view of coronal section.

C Split discus intervertebralis, anterior view of coronal section.

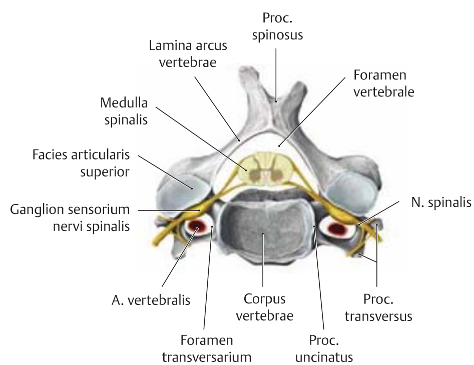
Clinical

Proximity of nervus spinalis and arteria vertebralis to the processus uncinatus

Nervus spinalis and arteria vertebralis pass through the foramen transversarium and foramina intervertebrale, respectively. Bony outgrowths (osteophytes) resulting from uncovertebral arthrosis may compress both the nerve and the artery and can lead to chronic pain in the neck.



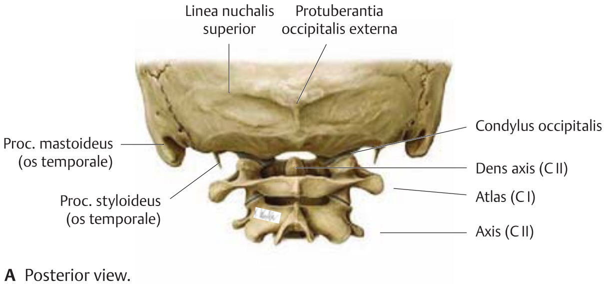
A Cervical spine, anterior view.



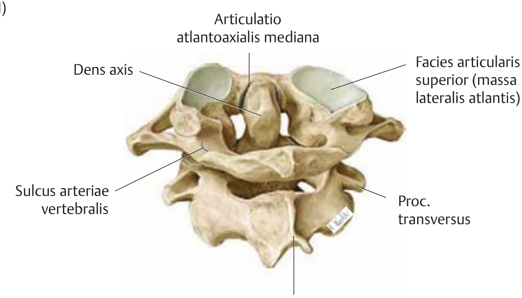
B Fourth cervical vertebra, superior view.

Joints of Columna Vertebralis: Craniovertebral Region

Fig. 1.24 **Craniovertebral joints**



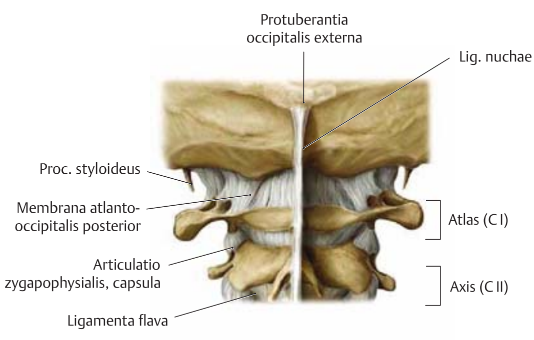
A Posterior view.



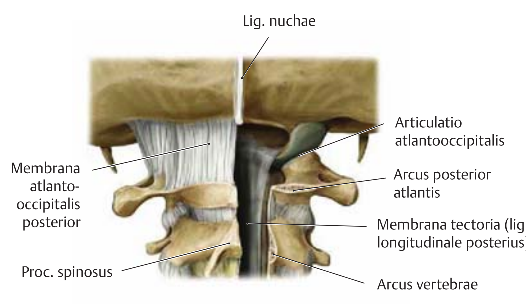
B Atlas (C I) and axis (C II), posterosuperior view.

Fig. 1.25 **Dissection of the craniovertebral joint ligaments**

Posterior view.



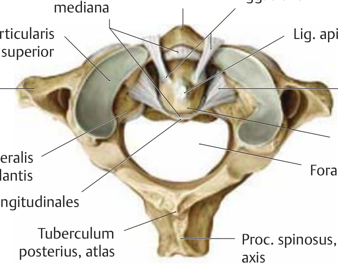
A Lig. nuchae and membrana atlanto-occipitalis posterior.



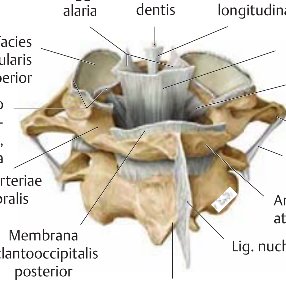
B Lig. longitudinale posterius. *Removed:* Medulla spinalis; canalis vertebrales windowed.

The atlanto-occipital joints are the two articulations between the convex condylus occipitalis of the occipital bone and the slightly concave facies articularis superior of the atlas (C I). The atlanto-axial joints are the two lateral and one medial articulations between the atlas (C I) and axis (C II).

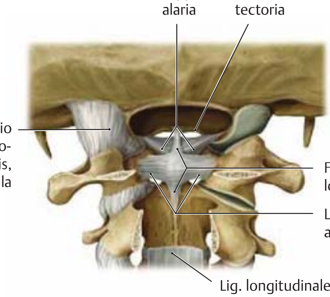
Fig. 1.26 Ligaments of the craniovertebral joints



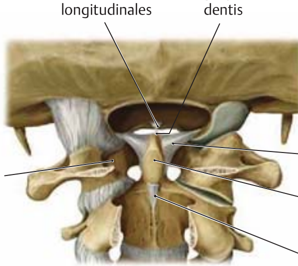
A Ligaments of articulatio atlantoaxialis mediana, superior view. Fovea dentis of the atlas is hidden by the joint capsule.



B Ligaments of the craniovertebral joints, posterosuperior view. Dens axis is hidden by membrana tectoria.



C Lig. cruciforme atlantis (*). *Removed:* Membrana tectoria.



D Ligg. alaria and lig. apicis dentis. *Removed:* Lig. transversum atlantis, fasciculi longitudinales.

Vertebral Ligaments: Overview & Cervical Spine

The ligaments of the spinal column bind the vertebrae and enable the spine to withstand high mechanical loads and shearing stresses and limit the range of motion. The ligaments are subdivided into vertebral body ligaments and vertebral arch ligaments.

Fig. 1.27 **Vertebral ligaments**
Viewed obliquely from the left posterior view.

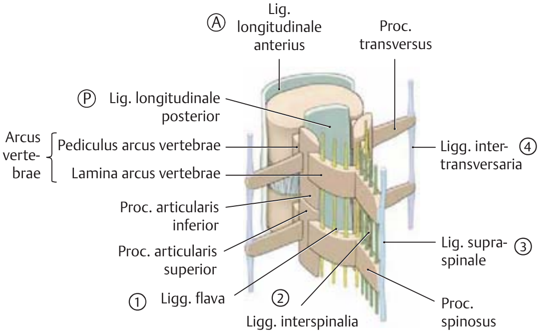


Table 1.3 **Vertebral ligaments**		
Ligament		**Location**
Vertebral body ligaments		
Ⓐ	Lig. longitudinale anterius	Along anterior surface of vertebral body
Ⓟ	Lig. longitudinale posterius	Along posterior surface of vertebral body
Vertebral arch ligaments		
①	Lig. flava	Between laminae
②	Ligg. interspinosi	Between procc. spinosi
③	Ligg. supraspinosi	Along posterior ridge of procc. spinosi
④	Ligg. intertransversarii	Between procc. transversi
Lig. nuchae*		Between external protuberancia occipitalis and proc. spinosus of C VII

*Corresponds to a lig. supraspinosum that is broadened superiorly.

Fig. 1.28 **Ligamentum longitudinale anterius**
Lig. longitudinale anterius. Anterior view with base of skull removed.

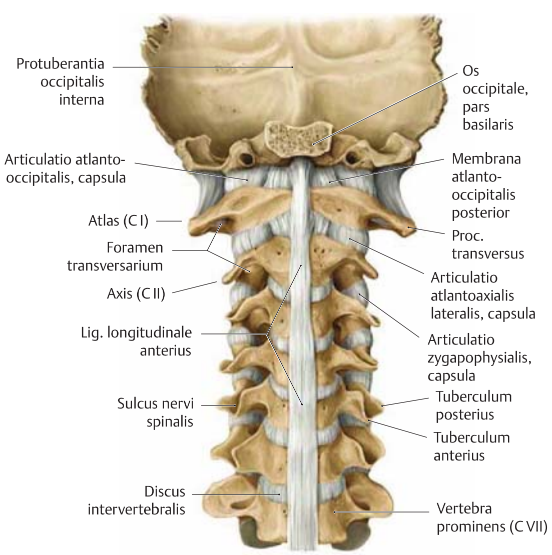


Fig. 1.29 **Ligamentum longitudinale posterius**
Posterior view with canalis vertebralis windowed and medulla spinalis removed. The membrana tectoria is a broadened expansion of lig. longitudinale posterius.

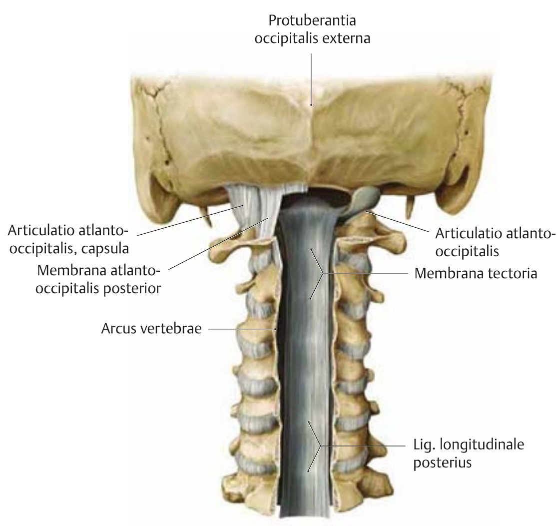
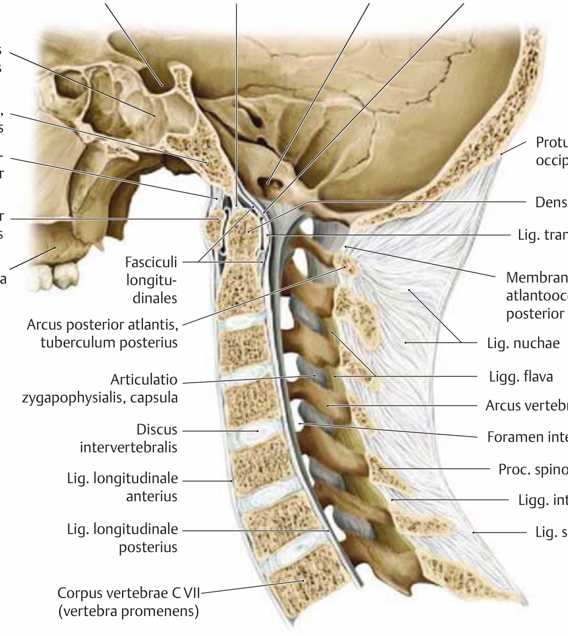


Fig. 1.30 **Ligaments of the cervical spine**



A Midsagittal section, left lateral view. Lig. nuchae is the broadened, sagittally oriented part of lig. supraspinale that extends from vertebra prominens (C VII) to protuberantia occipitalis externa.

B Midsagittal T2-weighted MRI, left lateral view.

Vertebral Ligaments: Thoracolumbar Spine

Fig. 1.31 **Ligaments of the vertebral column: Thoracolumbar junction**
Left lateral view of T XI–L III, with T XI–T XII sectioned in the midsagittal plane.

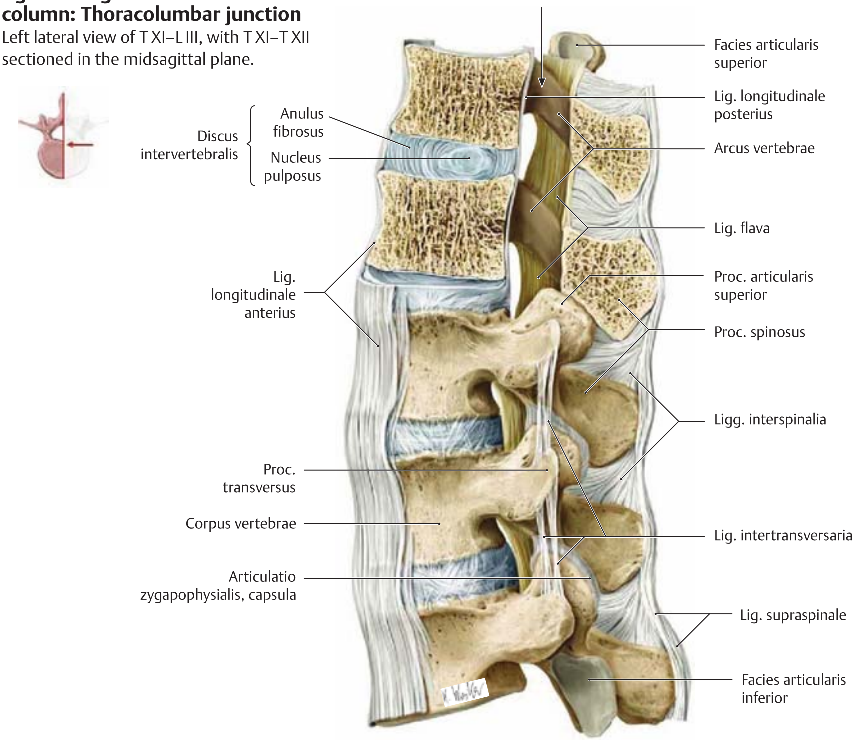


Fig. 1.32 **Ligamentum longitudinale anterius**
Anterior view of L III–L V.

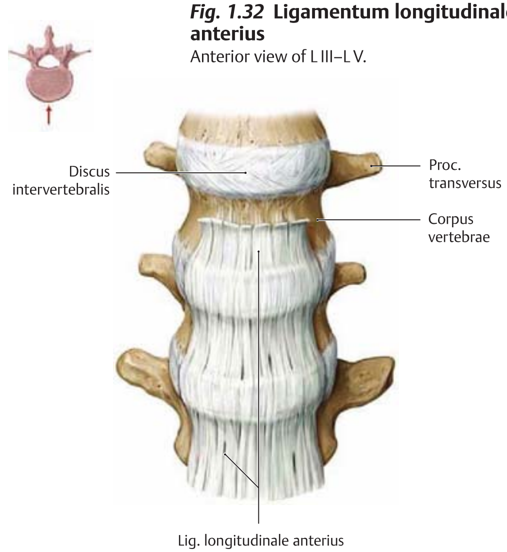


Fig. 1.33 **Ligamentum flavum and ligamenta intertransversaria**
Anterior view of opened canalis vertebralis at level of L II–L V. *Removed:* corpus vertebrae L II–L IV.

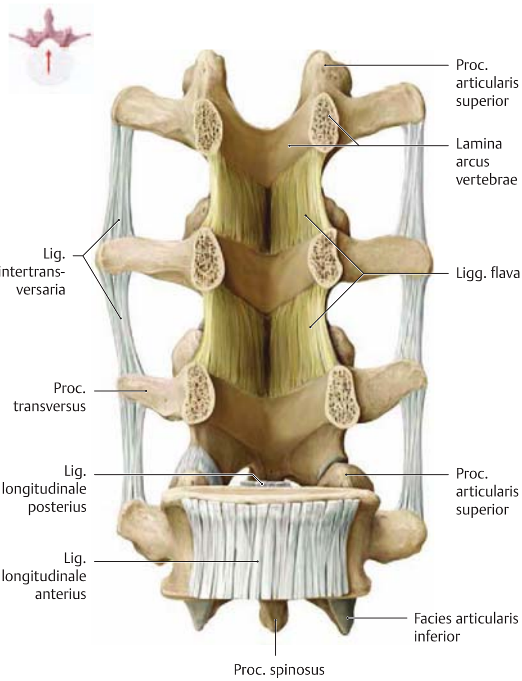
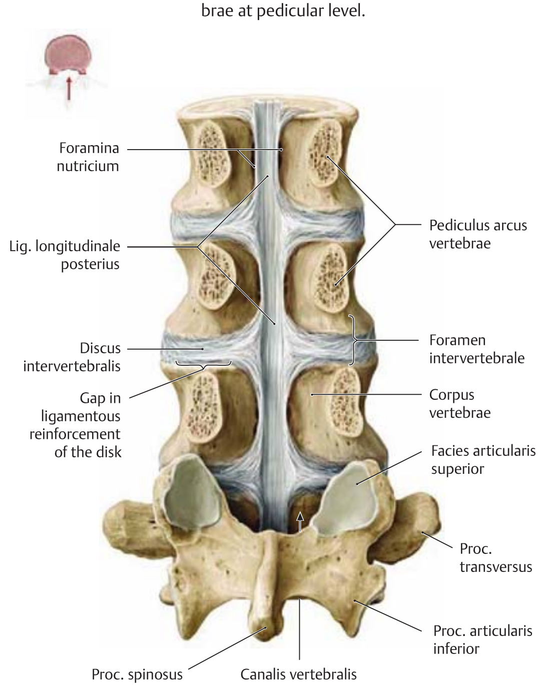


Fig. 1.34 **Ligamentum longitudinale posterius**
Posterior view of opened canalis vertebralis at level of L II–L V. *Removed:* L II–L IV arcus vertebrae at pedicular level.



Muscles of the Back: Overview

The muscles of the back are divided into two groups, the extrinsic and the intrinsic muscles, which are separated by lamina superficialis, fascia thoracolumbalis. The superficial extrinsic muscles are considered muscles of the upper limb that have migrated to the back; these muscles are discussed in Unit 4.

Fig. 2.1 **Superficial (extrinsic) muscles of the back**
Posterior view. *Removed:* M. trapezius and m. latissimus dorsi (right). *Revealed:* Fascia thoracolumbalis. *Note:* Lamina superficialis of the thoracolumbar fascia is reinforced by the aponeurotic origin of the latissimus dorsi.

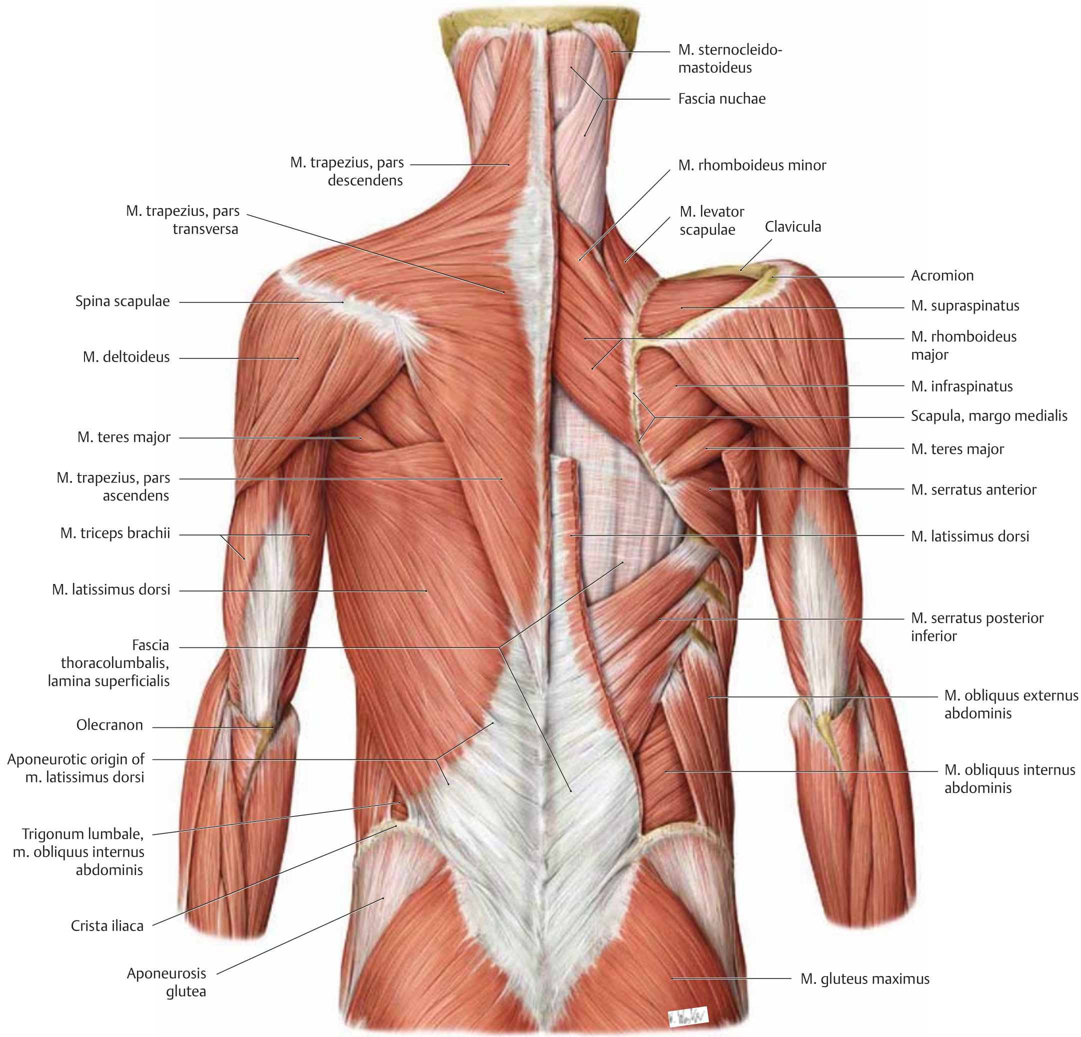
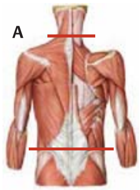
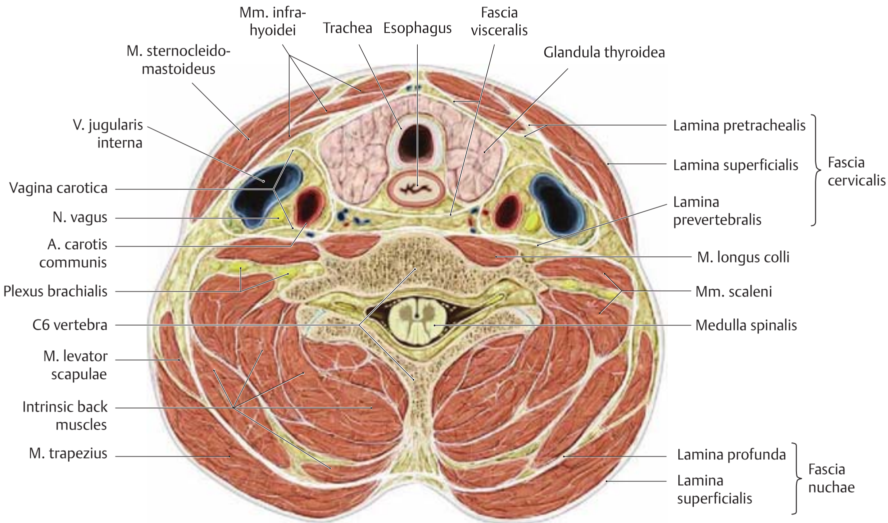


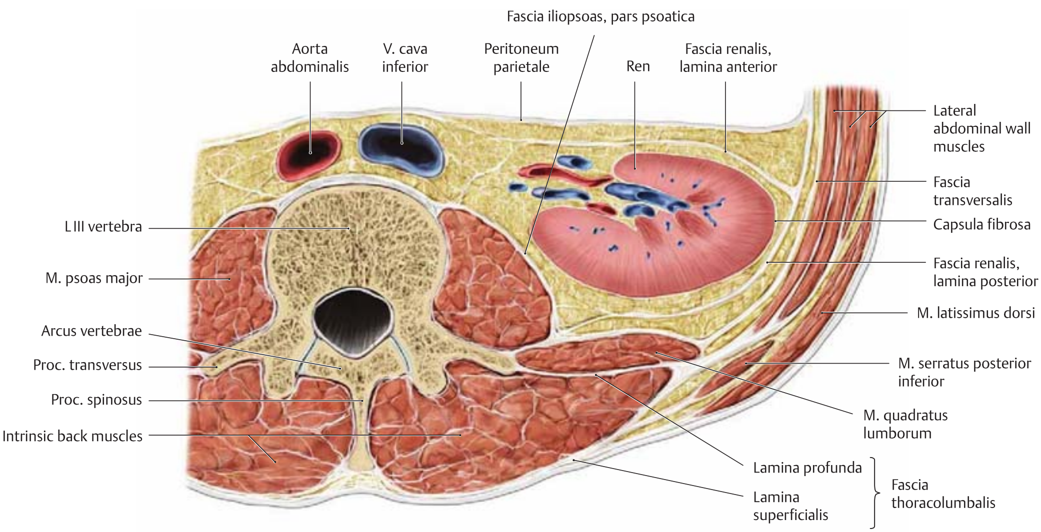
Fig. 2.2 **Fascia thoracolumbalis**

Transverse section, superior view. The intrinsic back muscles are sequestered in an osseofibrous canal, formed by fascia thoracolumbalis, archus, and processus spinosus and processus transversus of associated vertebrae. Fascia thoracolumbalis consists of a superficial layer, lamina superficialis, and a deep layer, lamina profunda, that unite at the lateral margin of the intrinsic back muscles. In the neck, the superficial layer blends with the fascia nuchae (deep layer), becoming continuous with fascia cervicalis (prevertebral layer).





A Transverse section at level of CVI vertebra, superior view.



B Transverse section at level of L III, superior view.
Removed: Cauda equina and anterior trunk wall.

Intrinsic Muscles of the Cervical Spine

Fig. 2.3 **Muscles in the nuchal region**
Posterior view. *Removed:* M. trapezius, m. sternocleidomastoid, m. splenius, and m. semispinalis (right). *Revealed:* Musculi cervicis (right).

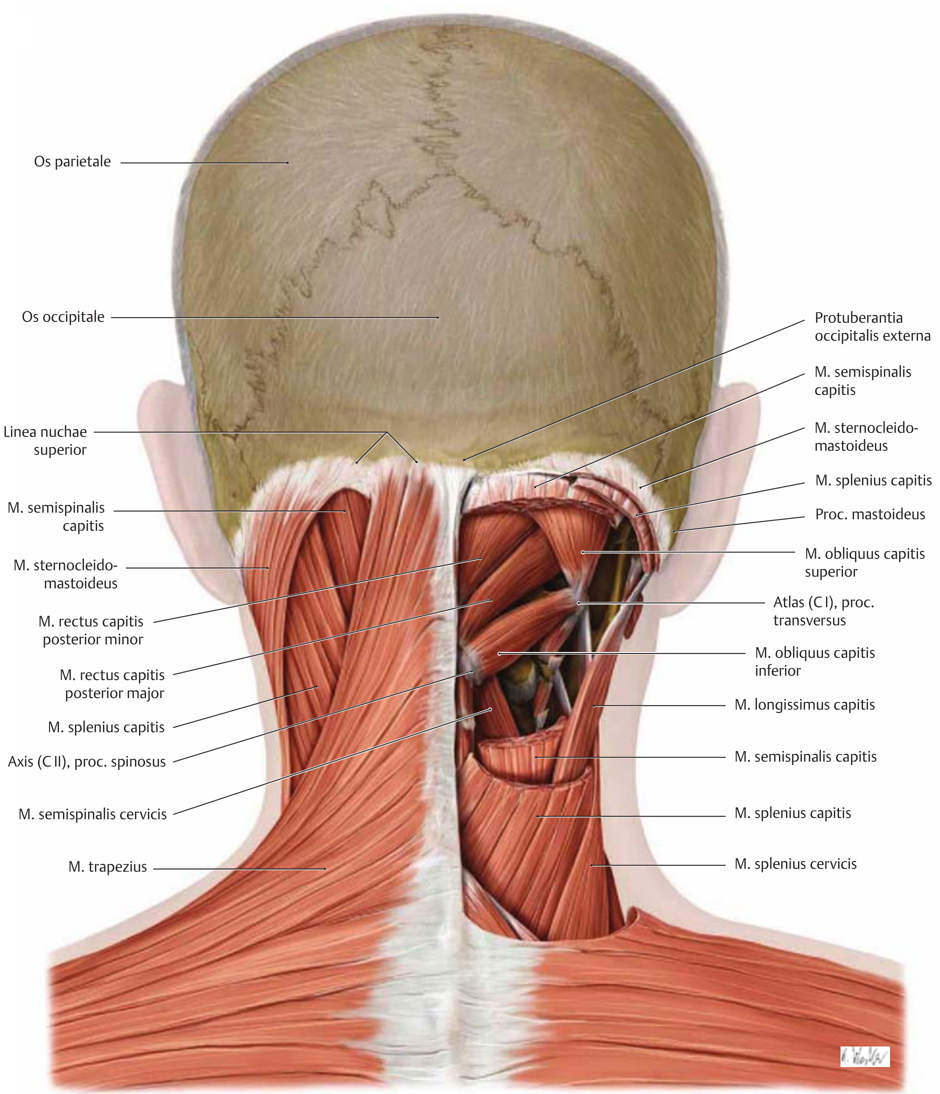
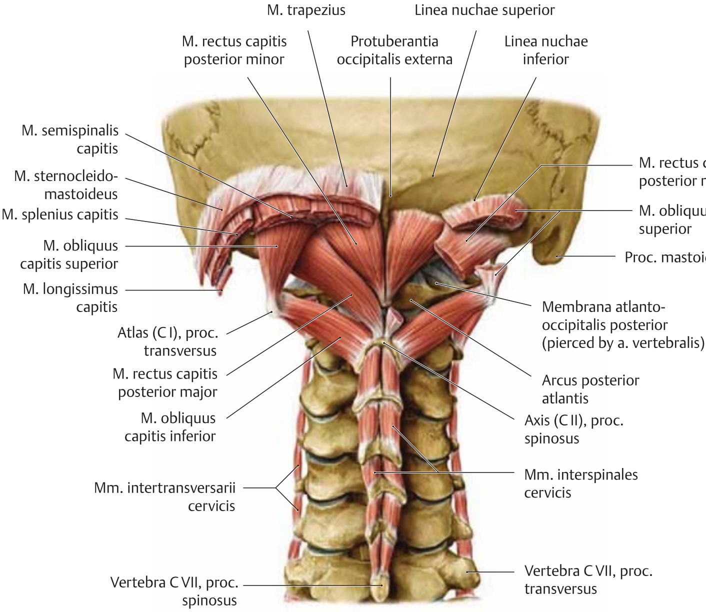
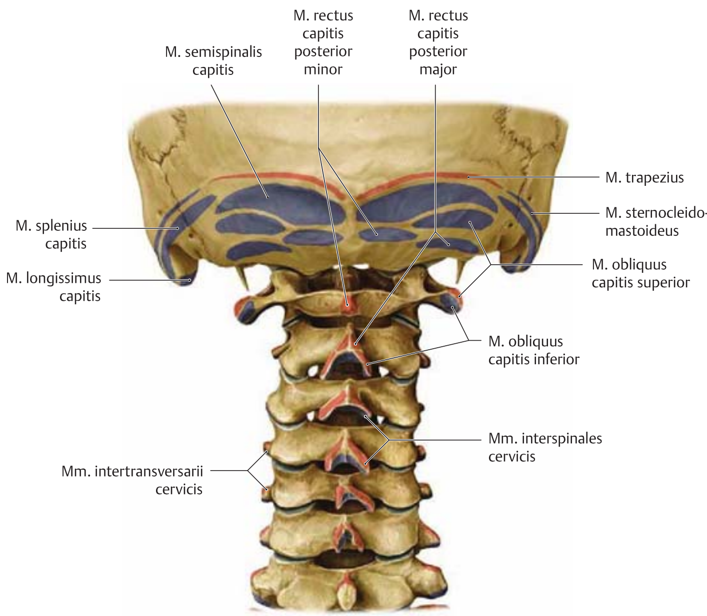


Fig. 2.4 **Short nuchal muscles**
Posterior view. See Fig. 2.6.



A Course of the short nuchal muscles.



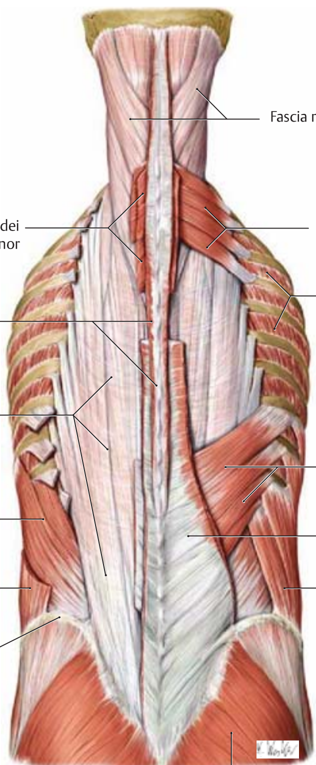
B Origins (red) and insertions (blue) in the suboccipital region.

Intrinsic Muscles of the Back

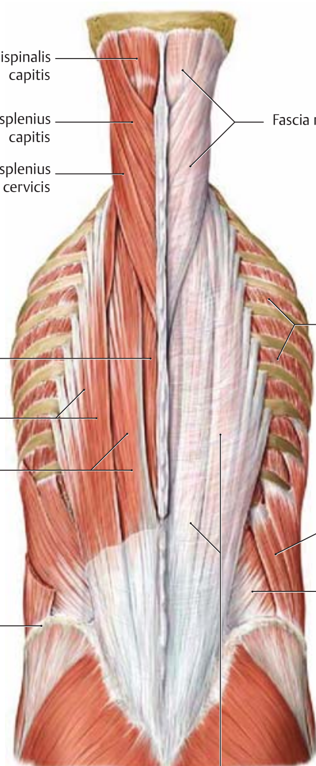
The extrinsic muscles of the back (m. trapezius, m. latissimus dorsi, m. levator scapulae, and m. rhomboideae) are discussed in Unit 4. M. serratus posterior, considered an intermediate extrinsic back muscle, has been included with the superficial intrinsic muscles in this unit.

Fig. 2.5 Intrinsic muscles of the back

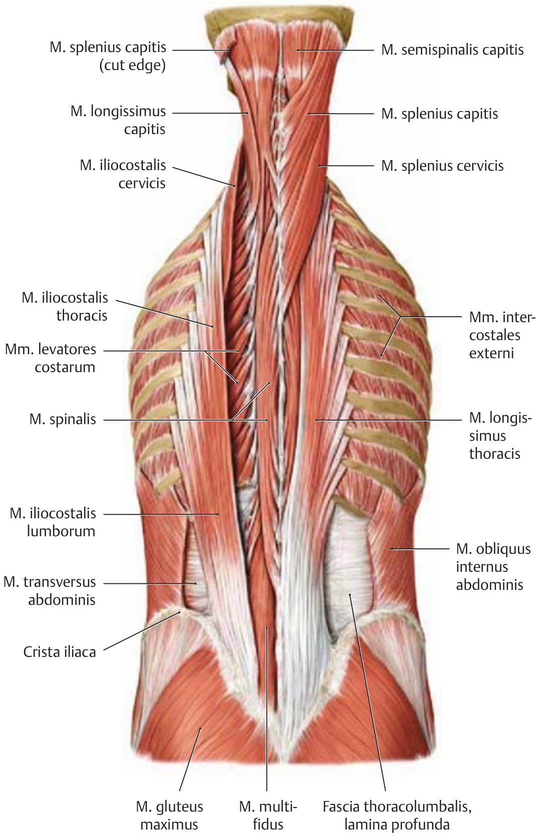
Posterior view. Sequential dissection of fascia thoracolumbalis, superficial intrinsic muscles, intermediate intrinsic muscles, and deep intrinsic muscles of the back.



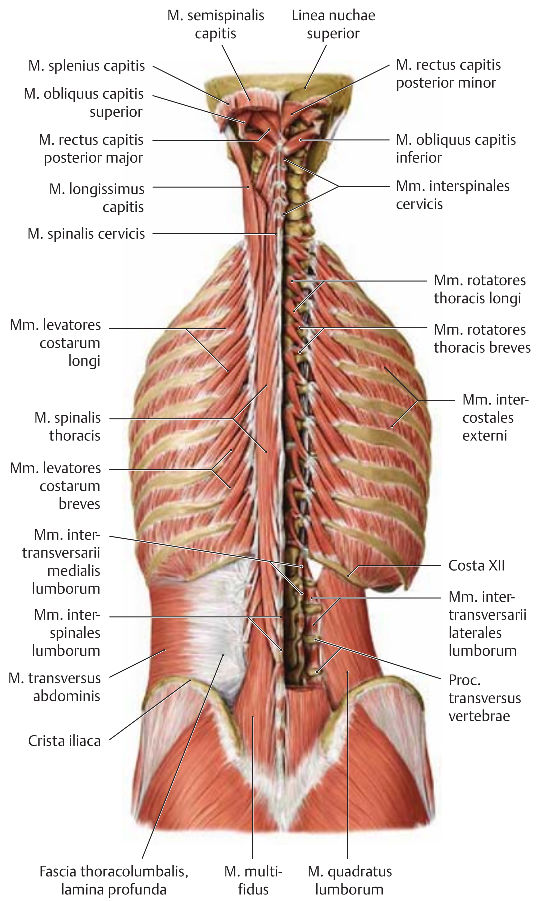
A Fascia thoracolumbalis. *Removed:* Shoulder girdles and extrinsic back muscles (except m. serratus posterior and aponeurotic origin of m. latissimus dorsi). *Revealed:* Lamina superficialis fascia thoracolumbalis.



B Superficial and intermediate intrinsic back muscles. *Removed:* Fascia thoracolumbalis (left). *Revealed:* M. erector spinae and m. splenius.



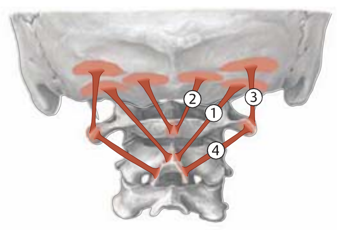
C Intermediate and deep intrinsic back muscles. *Removed:* M. longissimus thoracis and cervicis, m. splenius muscles (left); m. iliocostalis (right). *Note:* Lamina profunda of fascia thoracolumbalis gives origin to the internal oblique and transversus abdominus. *Revealed:* Deep muscles of the back.



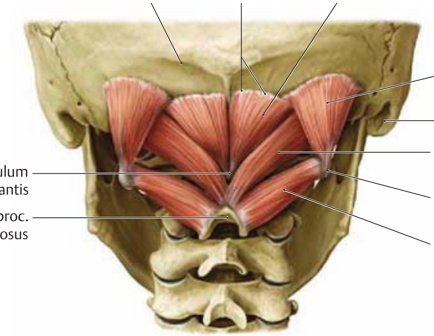
D Deep intrinsic back muscles. *Removed:* Superficial and intermediate intrinsic back muscles (all); deep fascial layer and m. multifidus (right). *Revealed:* M. intertransversarii and m. quadratus lumborum (right).

Muscle Facts (I)

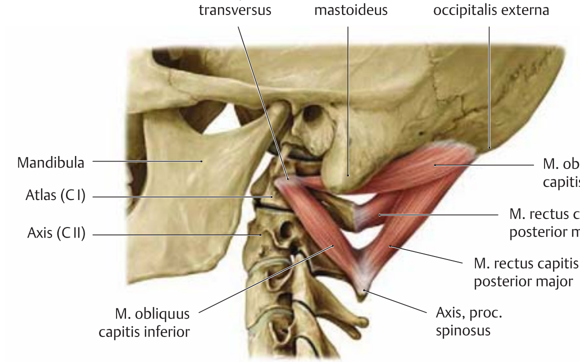
Fig. 2.6 **Short nuchal and craniovertebral joint muscles**



A Posterior view.



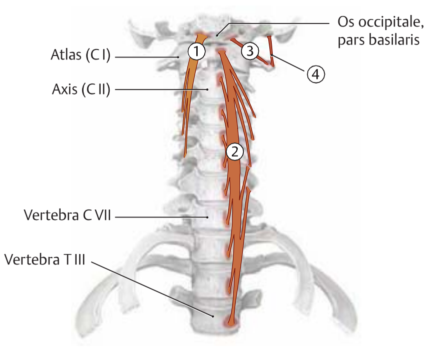
B Suboccipital muscles, posterior view.



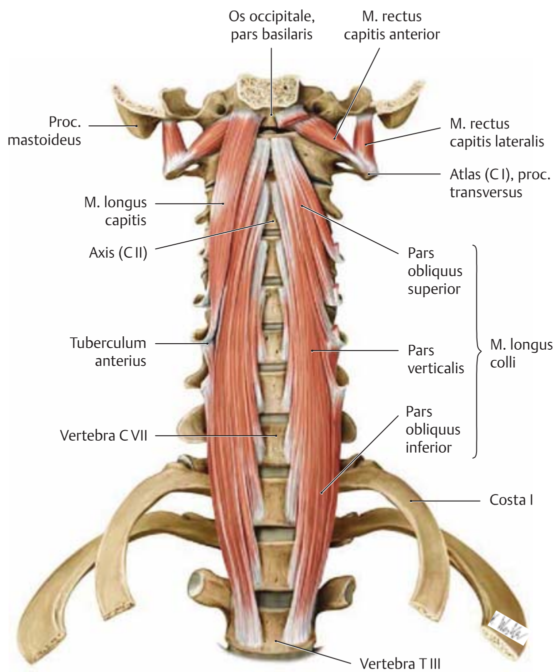
C Suboccipital muscles, left lateral view.

Table 2.1	**Short nuchal and craniovertebral joint muscles**				
Muscle		**Origin**	**Insertion**	**Innervation**	**Action**
M. rectus capitis posterior	① M. rectus capitis posterior major	C II (proc. spinosus)	Os occipitale (linea nuchalis inferior, middle third)	C1 (Ramus dorsalis = N. suboccipitalis)	*Bilateral:* Extends head *Unilateral:* Rotates head to same side
	② M. rectus capitis posterior minor	C I (tuberculum posterius)	Os occipitale (linea nuchalis inferior, inner third)		
M. obliquus capitis	③ M. obliquus capitis superior	C I (proc. transversus)	Os occipitale (linea nuchalis inferior, middle third; above m. rectus capitis posterior major)		*Bilateral:* Extends head *Unilateral:* Tilts head to same side; rotates to opposite side
	④ M. obliquus capitis inferior	C II (proc. spinosus)	C I (proc. transversus)		*Bilateral:* Extends head *Unilateral:* Rotates head to same side

Fig. 2.7 Prevertebral muscles



A Anterior view.



B Prevertebral muscles, anterior view. *Removed:* Longus capitis (left); cervical viscera.

Table 2.2 **Prevertebral muscles**

Muscle		Origin	Insertion	Innervation	Action
① M. longus capitis		C III–C VI (procc. transversi, tuberculi anteriores)	Os occipitale (pars basilaris)	Direct branches from plexus cervicalis (C1–C3)	*Bilateral:* Flexes head *Unilateral:* Tilts and slightly rotates head to same side
② M. longus colli (cervicis)	Pars verticalis (medial)	C V–T III (pars anterior of corpus vertebrae)	C II–C IV (pars anterior of corpus vertebrae)	Direct branches from plexus cervicalis (C2–C6)	*Bilateral:* Flexes cervical spine *Unilateral:* Tilts and rotates cervical spine to same side
	Pars obliquus superior	C III–C V (procc. transversi, tuberculi anteriores)	C I (procc. transversi, tuberculi anteriores)		
	Pars obliquus inferior	T I–T III (pars anterior of corpus vertebrae)	C V–C VI (procc. transversi, tuberculi anteriores)		
M. rectus capitis	③ M. rectus capitis anterior	C I (lateral mass)	Os occipitale (pars basilaris)	C1 (r. ventralis)	*Bilateral:* Flexion at articulatio atlantooccipitalis *Unilateral:* Lateral flexion at articulatio atlantooccipitalis
	④ M. rectus capitis lateralis	C I (proc. transversus)	Os occipitale (pars basilaris, lateral to condylus occipitalis)		

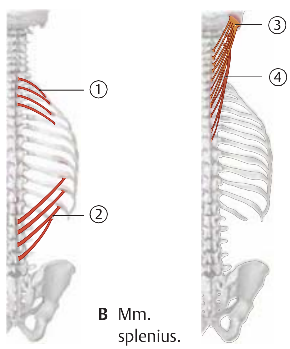
Muscle Facts (II)

The intrinsic back muscles are divided into superficial, intermediate, and deep layers. M. serratus posterior are extrinsic back muscles, innervated by the ventral rami of intercostal nerves, not the dorsal rami, which innervate the intrinsic back muscles. They are included here as they are encountered in dissection of the back musculature.

Table 2.3 Superficial intrinsic back muscles

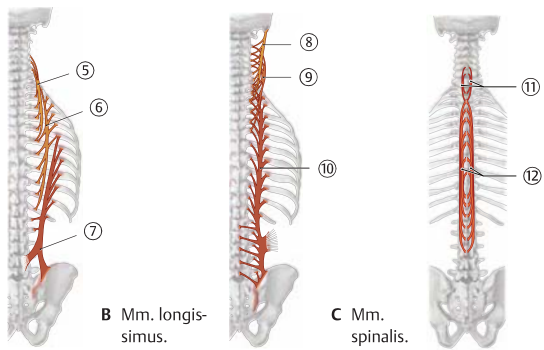
Muscle		Origin	Insertion	Innervation	Action
M. serratus posterior	① M. serratus posterior superior	Lig. nuchae; C VII–T III (procc. spinosi)	Costa II–IV (superior borders)	2nd–5th Nn. intercostales	Elevates ribs
	② M. serratus posterior inferior	T XI–L II (procc. spinosi)	Costa VIII–XII (inferior borders, near anguli)	Nn. spinales T9–T12 (r. ventralis)	Depresses ribs
Mm. splenii	③ M. splenius capitis	Ligamentum nuchae; C VII–T III (procc. spinosi)	Os occipitale (lateral linae nuchalis superior; proc. mastoideus)	Nn. spinales C1–C6 (r. dorsalis, lateral branches)	*Bilateral:* Extends cervical spine and head *Unilateral:* Flexes and rotates head to the same side
	④ M. splenius cervicis	T III–T VI (procc. spinosi)	C I–C II (procc. transversi)		

Fig. 2.8 **Superficial intrinsic back muscles (schematic)**
Right side, posterior view.



A M. serratus posterior. **B** Mm. splenius.

Fig. 2.9 **Intermediate intrinsic back muscles (schematic)**
Right side, posterior view. These muscles are collectively known as the erector spinae.

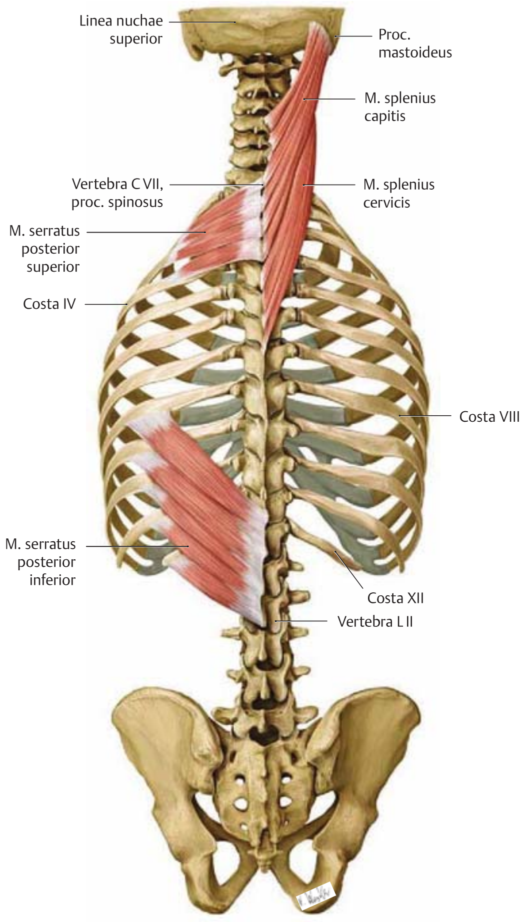


A Mm. iliocostalis. **B** Mm. longissimus. **C** Mm. spinalis.

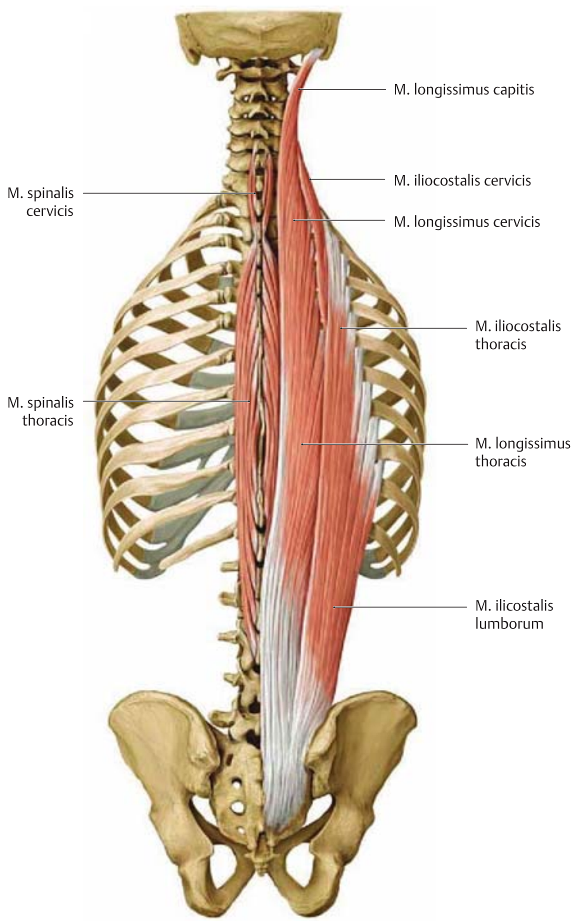
Table 2.4 Intermediate intrinsic back muscles

Muscle		Origin	Insertion	Innervation	Action
Mm. iliocostales	⑤ M. iliocostalis cervicis	Costa III–VII	C IV–C VI (procc. transversi)	Nn. spinales C8–L1 (r. dorsalis, lateral branches)	*Bilateral:* Extends spine *Unilateral:* Bends spine laterally to same side
	⑥ M. iliocostalis thoracis	Costa VII–XII	Costa I–VI		
	⑦ M. illiocostalis lumborum	Os sacrum; crista iliaca; fascia thoracolumbalis	Costa VI–XII; fascia thoracolumbalis (deep layer); upper vertebrae lumbales (procc. transversi)		
Mm. longissimi	⑧ M. longissimus capitis	T I–T III (procc. transversi); C IV–C VII (procc. transversi and articulares)	Os temporale (proc. mastoideus)	Nn. spinales C1–L5 (r. dorsalis, lateral branches)	*Bilateral:* Extends head *Unilateral:* Flexes and rotates head to same side
	⑨ M. longissimus cervicis	T I–T VI (procc. transversi)	C II–C V (procc. transversi)		*Bilateral:* Extends spine *Unilateral:* Bends spine laterally to same side
	⑩ M. longissimus thoracis	Os sacrum; crista iliaca; vertebrae lumbales (procc. spinosi); lower vertebrae thoracicae (procc. transversi)	Costa II–XII; vertebrae lumbales (procc. costalis); vertebrae thoracicae (procc. transversi)		
Mm. spinales	⑪ M. spinalis cervicis	C V–T II (procc. spinosi)	C II–C V (procc. spinosi)	Nn. spinales (r. dorsalis)	*Bilateral:* Extends cervical and thoracic spine *Unilateral:* Bends cervical and thoracic spine to same side
	⑫ M. spinalis thoracis	T X–L III (procc. spinosi, lateral surfaces)	T II–T VIII (procc. spinosi, lateral surfaces)		

Fig. 2.10 **Superficial and intermediate intrinsic back muscles**
Posterior view.



A M. splenius and m. serratus posterior.



B M. erector spinae: m. iliocostalis, longissimus, and spinalis.

Muscle Facts (III)

The deep intrinsic back muscles are divided into two groups: transversospinal and deep segmental muscles. The transversospinalis muscles pass between the transverse and spinous processes of the vertebrae.

Table 2.5 Transversospinalis muscles

Muscle		Origin	Insertion	Innervation	Action
Mm. rotatores	① Mm. rotatores breves	T I–T XII (between procc. transversi and spinosi of adjacent vertebrae)		Nn. spinales (r. dorsalis)	*Bilateral:* Extends thoracic spine *Unilateral:* Rotates spine to opposite side
	② Mm. rotatores longi	T I–T XII (between procc. transversi and spinosi, skipping one vertebra)			
Mm. multifidi ③		C II–sacrum (procc. transversi and spinosi, skipping two to four vertebrae)			*Bilateral:* Extends spine *Unilateral:* Flexes spine to same side, rotates to opposite side
Mm. semispinales	④ M. semispinalis capitis	C IV–T VII (procc. transversi and articulares)	Os occipitale (between linae nuchalis superior and inferior)		*Bilateral:* Extends thoracic and cervical spines and head (stabilizes articulationes craniovertebrales) *Unilateral:* Bends head, cervical and thoracic spines to same side, rotates to opposite side
	⑤ M. semispinalis cervicis	T I–T VI (procc. transversi)	C II–C V (procc. spinosi)		
	⑥ M. semispinalis thoracis	T VI–T XII (procc. transversi)	C VI–T IV (procc. spinosi)		

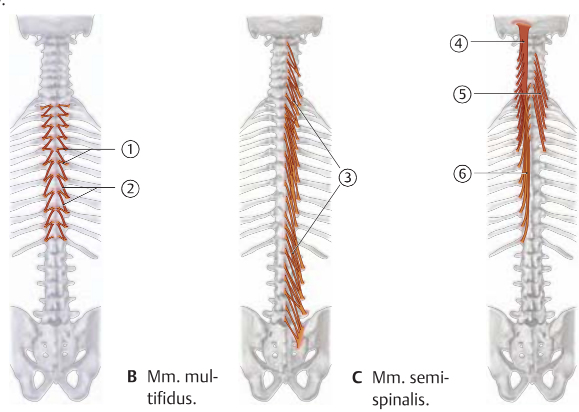


Fig. 2.11 **Transversospinalis muscles (schematic)**
Posterior view.

A Mm. rotatores. **B** Mm. multifidus. **C** Mm. semispinalis.

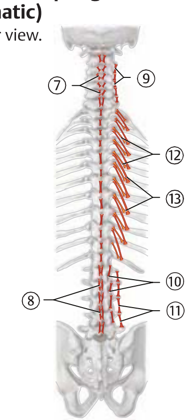


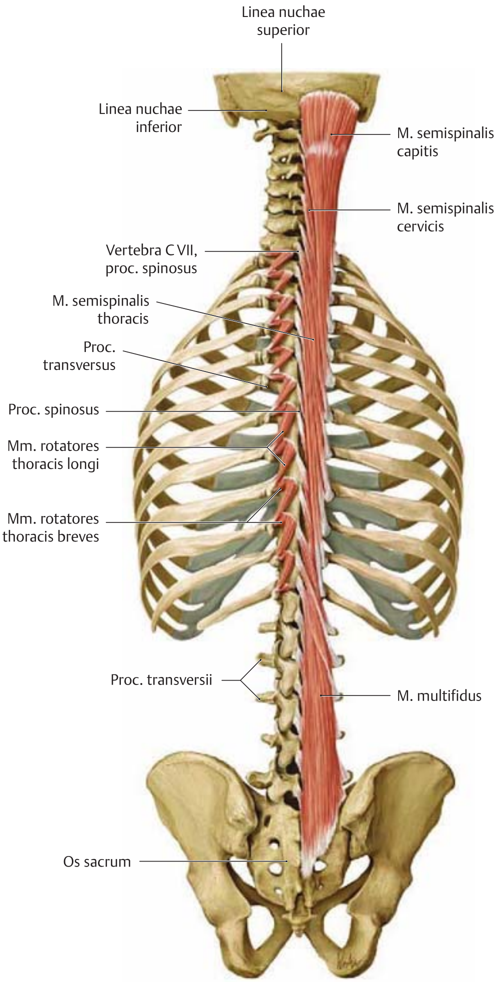
Fig. 2.12 **Deep segmental muscles (schematic)**
Posterior view.

Table 2.6 Deep segmental back muscles

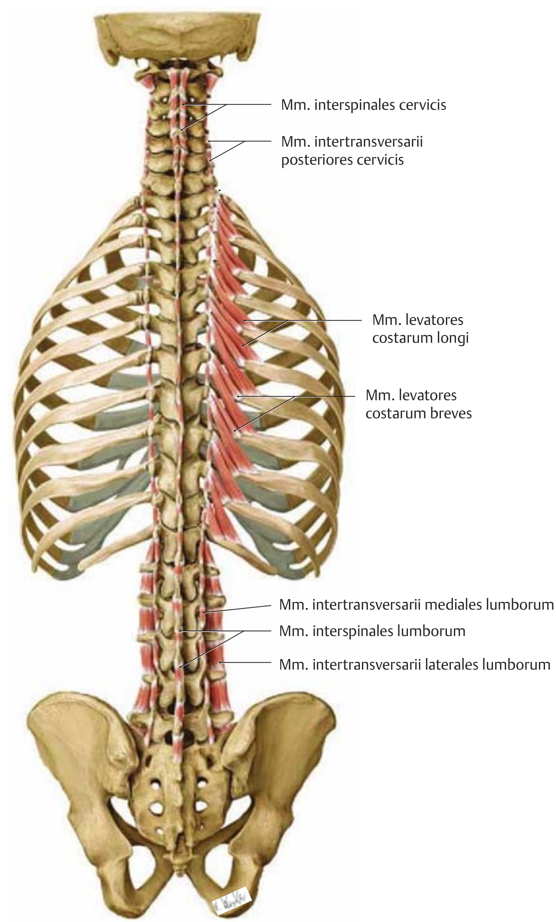
Muscle		Origin	Insertion	Innervation	Action
Mm. interspinales*	⑦ Mm. interspinales cervicis	C I–C VII (between procc. spinosi of adjacent vertebrae)		Nn. spinales (r.dorsalis)	Extends cervical and lumbar spines
	⑧ Mm. interspinales lumborum	L I–L V (between procc. spinosi of adjacent vertebrae)			
Mm. intertransversarii*	Mm. intertransversarii anterior cervicis	C II–C VII (between tuberculi anteriores of adjacent vertebrae)		Nn. spinales (r. ventralis)	*Bilateral:* Stabilizes and extends the cervical and lumbar spines *Unilateral:* Bends the cervical and lumbar spines laterally to same side
	⑨ Mm. intertransversarii posterior cervicis	C II–C VII (between tuberculi posteriores of adjacent vertebrae)		Nn. spinales (r. dorsalis)	
	⑩ Mm. intertransversarii mediales lumborum	L I–L V (between procc. mammilarii of adjacent vertebrae)			
	⑪ Mm. intertransversarii laterales lumborum	L I–L V (between procc. transversi of adjacent vertebrae)			
Mm. levatores costarum	⑫ Mm. levatores costarum breves	C VII–T XI (procc. transversi)	Angulus costae of next lower rib		*Bilateral:* Extends thoracic spine *Unilateral:* Bends thoracic spine to same side, rotates to opposite side
	⑬ Mm. levatores costarum longi		Angulus costae of rib two vertebrae below		

*Both the mm. interspinales and mm. intertransversarii traverse the entire spine; only their clinically relevant components have been included.

Fig. 2.13 **Deep intrinsic back muscles**
Posterior view.



A Transversospinalis muscles: Mm. rotatores, mm. multifidus, and mm. semispinalis.

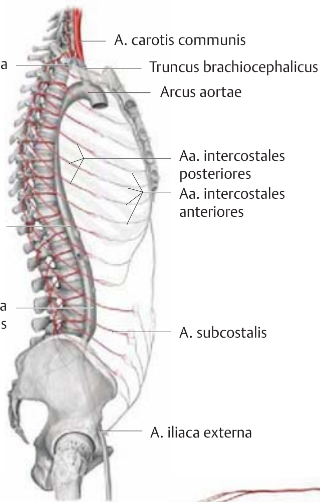


B Deep segmental muscles: Mm. interspinales, mm. intertransversarii, and mm. levatores costarum.

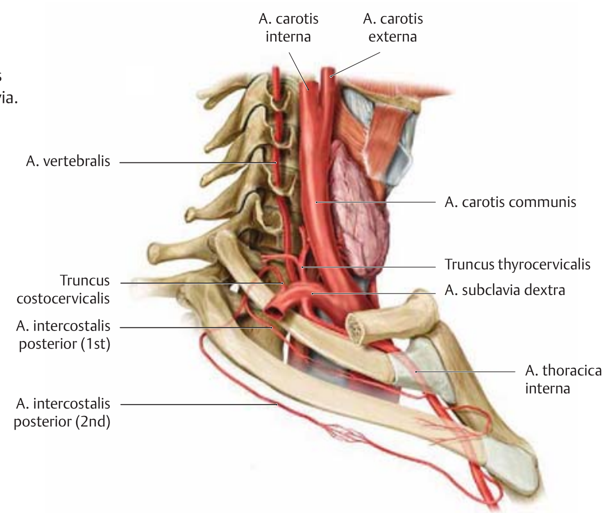
Arteries & Veins of the Back

Fig. 3.1 Arteries of the back

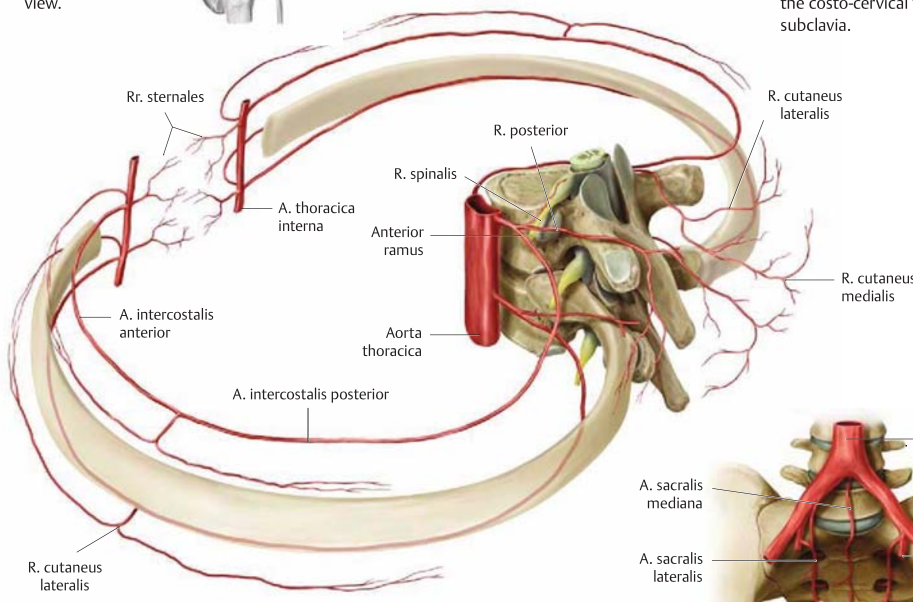
The structures of the back are supplied by branches of a. intercostalis posterior, which arise from aorta thoracica or directly from a. subclavia.



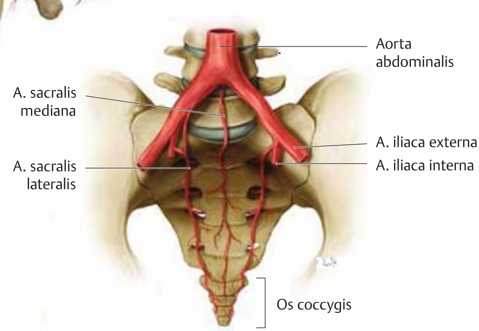
A Arteries of the trunk, right lateral view.



B Vascular supply to the nuchal region, posterolateral view. *Note:* The first and second aa. intercostales posteriores arise from the costo-cervical trunk, a branch of a. subclavia.



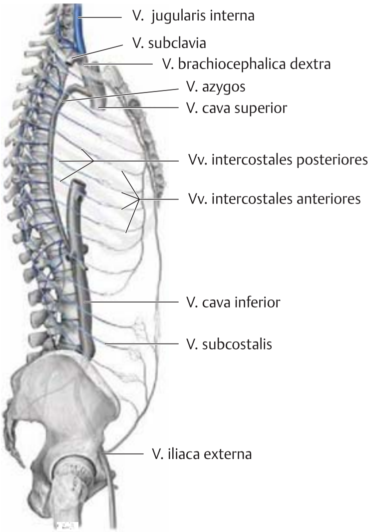
C Aa. intercostales posteriores, oblique posterosuperior view. The posterior intercostal arteries give rise to cutaneous and muscular branches, as well as spinal branches that supply the spinal cord.



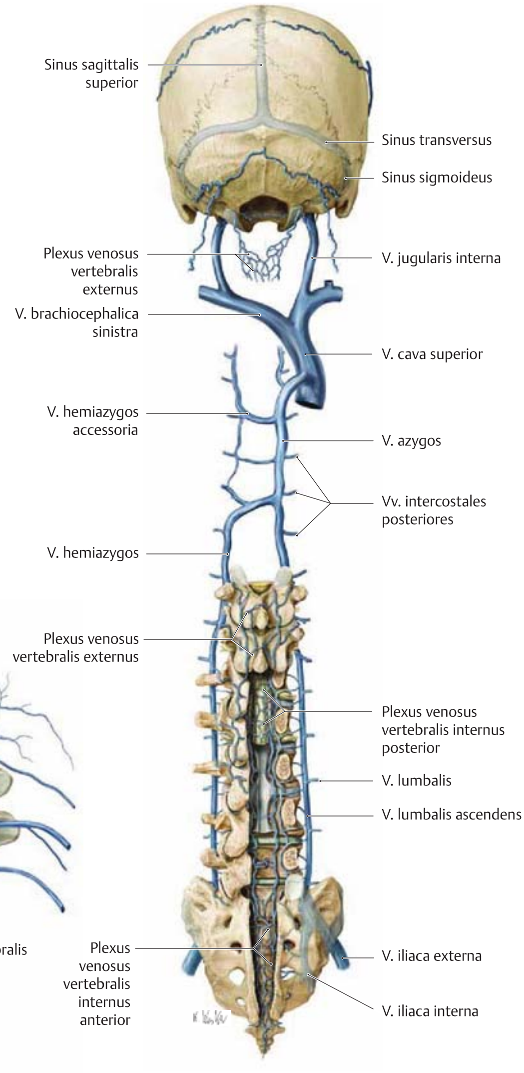
D Vascular supply to the sacrum, anterior view.

Fig. 3.2 Veins of the back

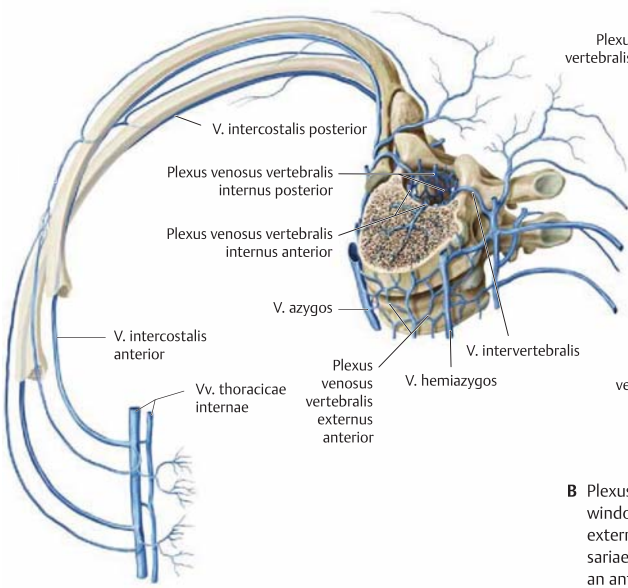
The veins of the back drain into v. azygos via vv. intercostales superiores, vv. hemiazygos, and vv. lumbales ascendens. The interior of the spinal column is drained by plexus venosus vertebralis that runs the length of the spine.



A Veins of the trunk, right lateral view.



B Plexus venosus vertebralis, posterior view with canalis vertebralis windowed in the lumbar and sacral spine. Plexus venosus vertebralis externus communicates with the sinussigmoidas through vv. emissariae in the skull. Plexus venosus vertebralis externus is divided into an anterior and a posterior portion that run along the exterior of the spinal column. Plexus venosus vertebralis internus anterior and posterior run in the foramen vertebrale and drain the spinal cord.

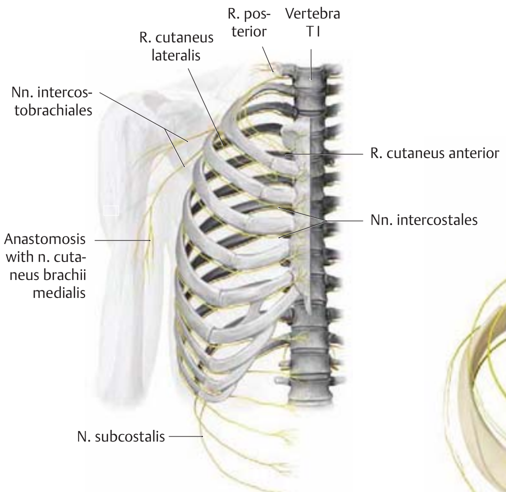


C Vv. intercostalis and plexus venosus vertebralis anterior, anterosuperior view. The intercostal veins follow a similar course as the intercostal nerves and arteries (see pp. 34, 36).*Note:* Plexus venosus vertebralis externus anterior can be seen communicating with v. azygos.

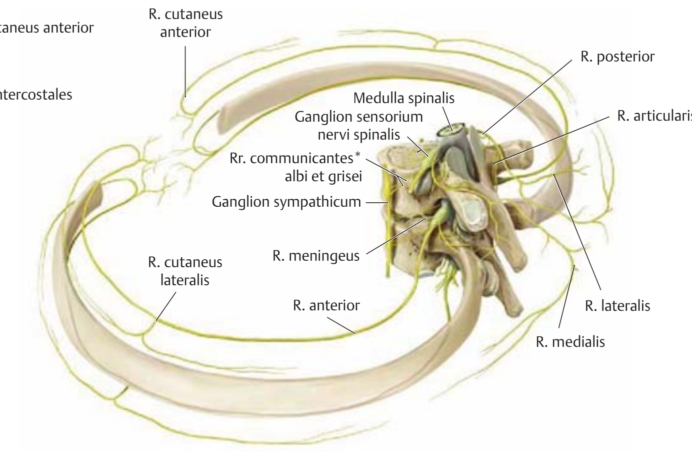
Nerves of the Back

The back receives its innervation from branches of nn. spinales. The *posterior* rami of the spinal nerves supply most of the intrinsic muscles of the back. The extrinsic muscles of the back are supplied by the *anterior* rami of the spinal nerves.

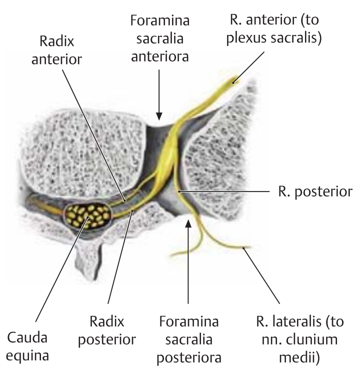
Fig. 3.3 **Nerves of the back**
The anterior rami of n. spinalis T1–T11 form nn. intercostales, which course along the ribs and give rise to lateral and anterior cutaneous branches, rami cutaneri.



A Course of nn. intercostales.



B Nn. intercostales branches, superior view. Rami posteriores of nn. spinales give rise to muscular and cutaneous branches, as well as articular branches to the zygapophyseal joints. Rami anteriores of nn. spinales T1–T11 produce nn. intercostales (T12 produces n. subcostalis).



C Nn. spinales branches in the sacral foramina. Superior view of transverse section through right half of sacrum.

Table 3.1 **Branches of a spinal nerve**

Branches			Territory
R. meningeus			Spinal meninges; ligaments of spinal column
R. dorsalis	Medial branches	Articular branch	Articulationes zygapophyseales
		Muscular branch	Intrinsic back muscles
		Cutaneous branch	Skin of posterior head, neck, back, and buttocks
	Lateral branches	Cutaneous branch	
		Muscular branch	Intrinsic back muscles
R. ventralis	Lateral cutaneous branches		Skin of lateral chest wall
	Anterior cutaneous branches		Skin of anterior chest wall

*The white and gray rami communicans carry pre- and postganglionic fibers between the sympathetic trunk and spinal nerve. They are shown on p. 622.

Fig. 3.4 **Nerves of the nuchal region**
Right side, posterior view. Like the back, the nuchal region receives most of its motor and sensory innervation from rami *posteriores* of nn. spinales. Rami posteriores of C1–C3 have specific names: n. suboccipital (C1), n. occipitalis major (C2), and n. occipitalis tertius (C3). N. occipitalis minor and n. auricularis major arise from the rami *anteriores* of the C1–C4 spinal nerves and innervate the skin of the anterolateral head and neck. Rami anteriores of C1–C4 also give rise to the *ansa cervicalis,* which innervates mm. infrahyoidales (see p. 562).

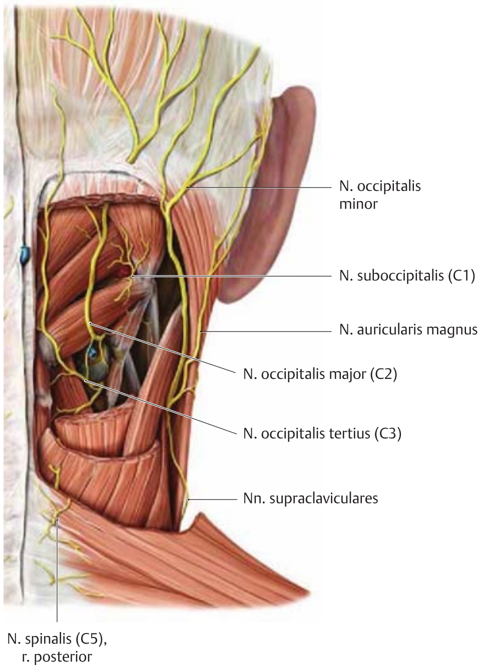
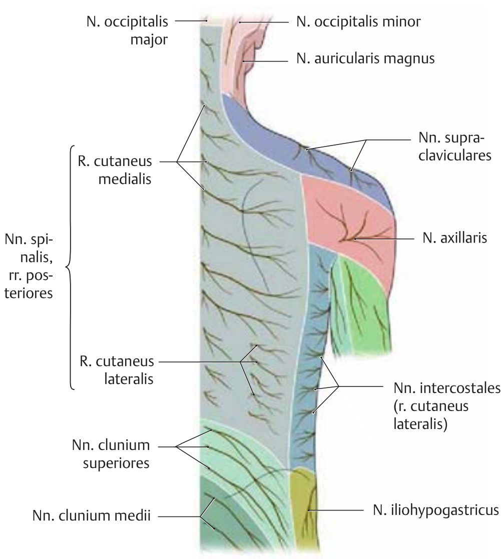
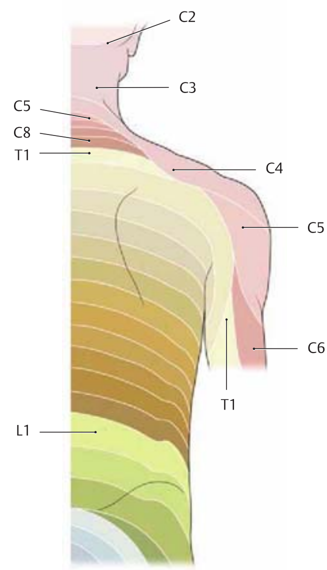


Fig. 3.5 **Cutaneous innervation of the back**



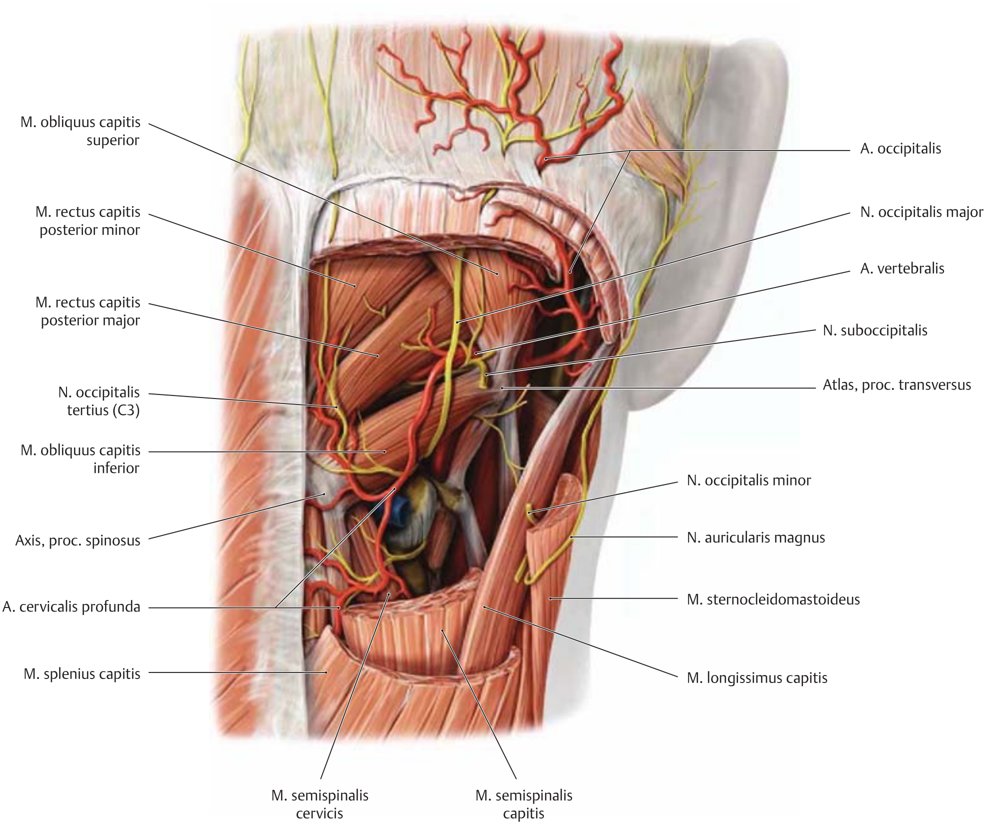
A Peripheral sensory cutaneous innervation of the back.



B Dermatomes: Segmental (radicular) cutaneous innervation of the back. *Note*: Ramus posterior of C1 is purely motor; there is consequently no C1 dermatome.

Neurovascular Topography of the Back

Fig. 3.6 **Neurovasculature of the nuchal region**
Posterior view. *Removed:* M. trapezius, m. sternocleidomastoid, m. splenius capitis, and m. semispinalis capitis. *Revealed:* Suboccipital region. See p. 60 for the course of the intercostal vessels.



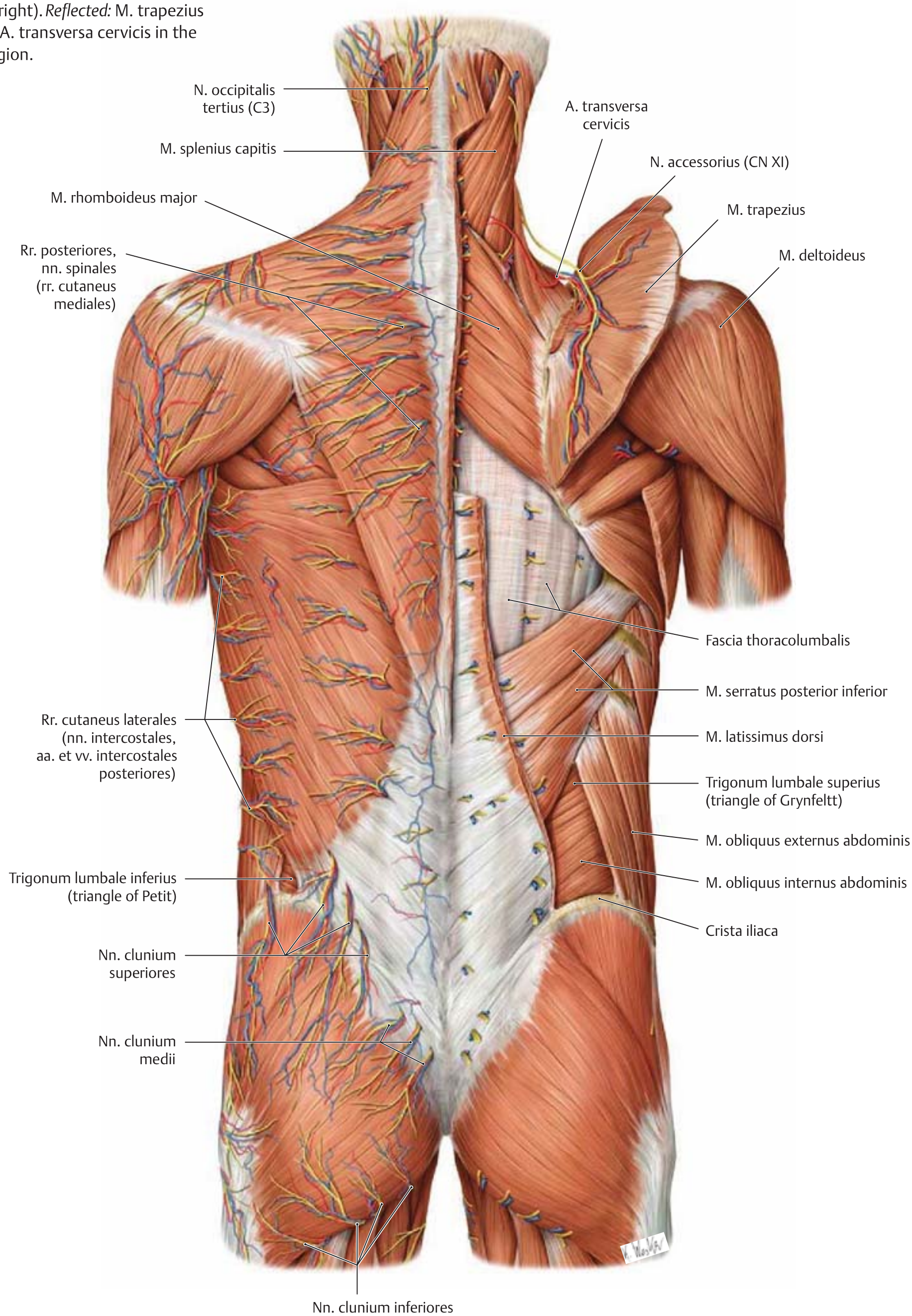
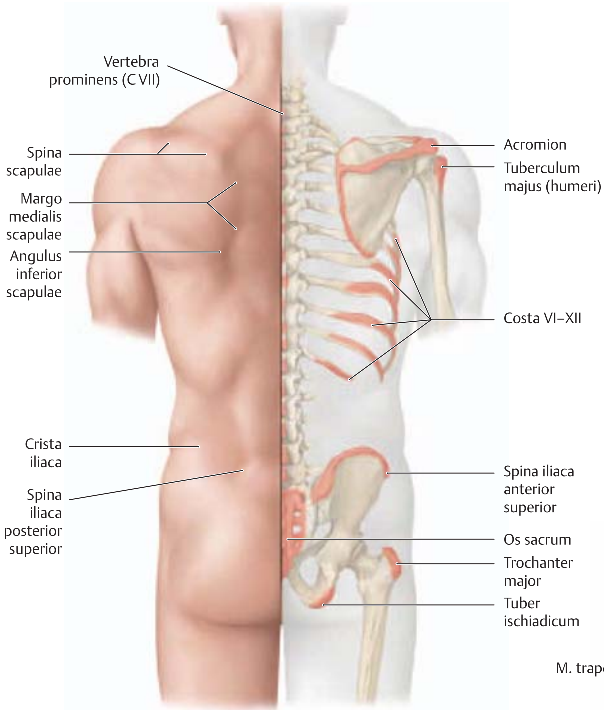


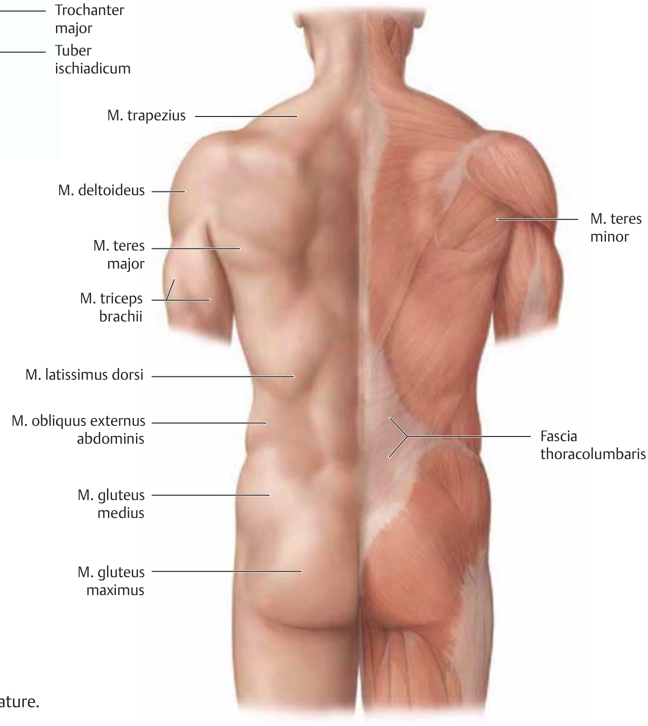
Fig. 3.7 **Neurovasculature of the back**
Posterior view. *Removed:* Muscle fascia (except fascia thoracolumbalis, lamina superficialis); m. latissimus dorsi (right). *Reflected:* M. trapezius (right). *Revealed:* A. transversa cervicis in the deep scapular region.

Surface Anatomy

Fig. 4.1 **Palpable structures in the back**
Posterior view.



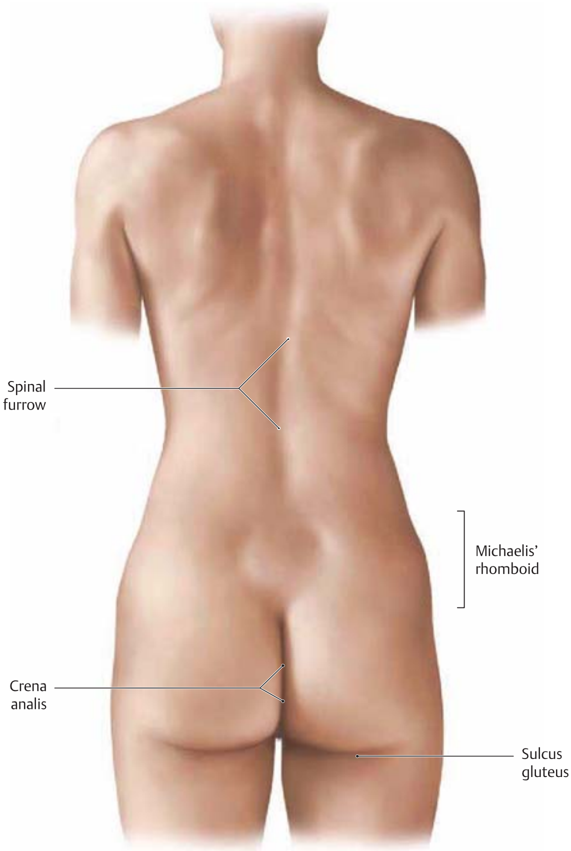
A Bony prominences.



B Musculature.

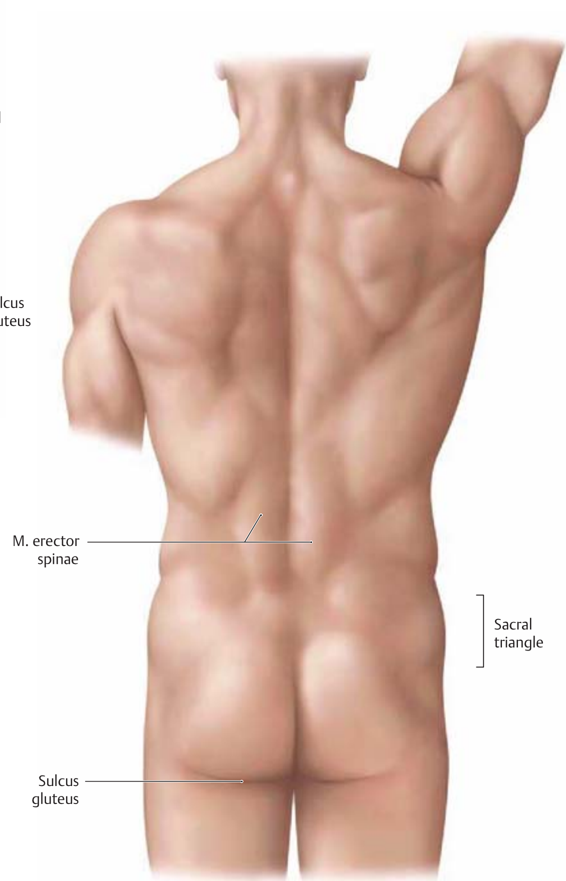
Fig. 4.2 **Surface anatomy of the back**
Posterior view.

Q1: Michaelis' rhomboid can be used as an indicator of the width of the female pelvis. What are its boundaries?



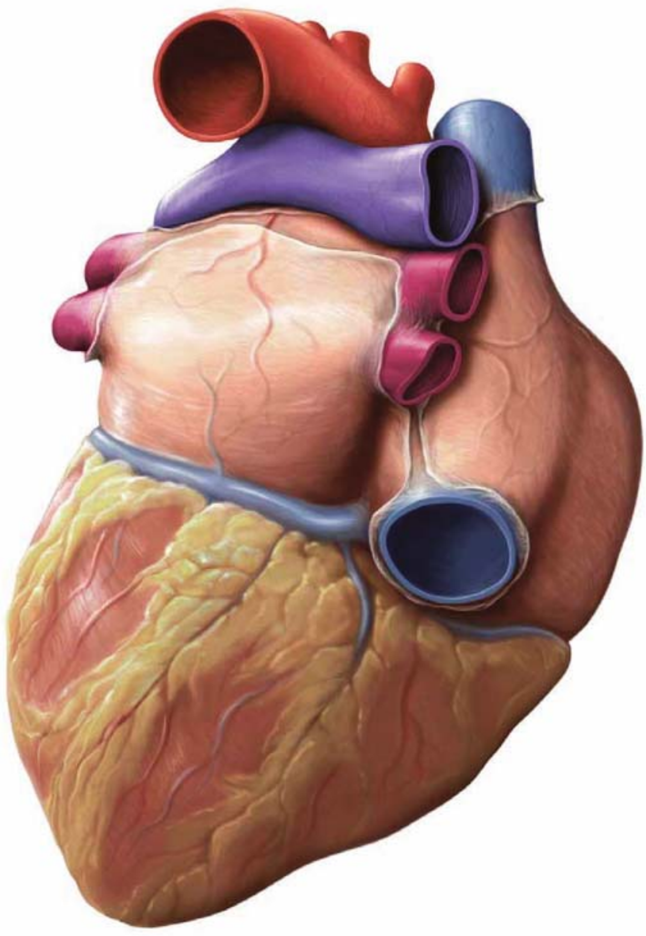
A Female back.

Q2: The limb girdles are reliable indicators of specific vertebral levels. What level corresponds to the angulus interior of the scapula? What level corresponds to the crista iliaca?



See answers beginning on p. 626.

B Male back.



Thorax

5 Thoracic Wall

6 Thoracic Cavity

7 Mediastinum

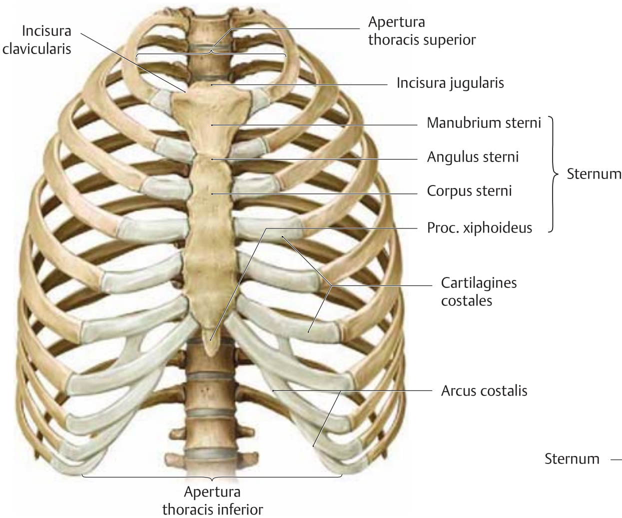
8 Pleural Cavity

9 Surface Anatomy

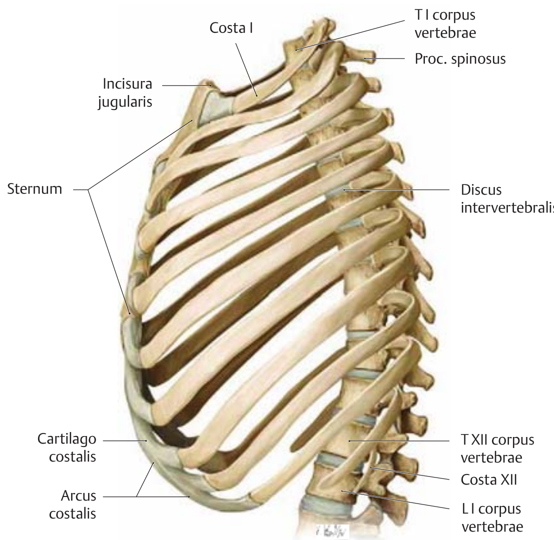
Thoracic Skeleton

The thoracic skeleton consists of 12 vertebrae thoracicae (p. 8), 12 pairs of ribs with costal cartilages, and the sternum. In addition to participating in respiratory movements, it provides a measure of protection to vital organs. The female thorax is generally narrower and shorter than the male equivalent.

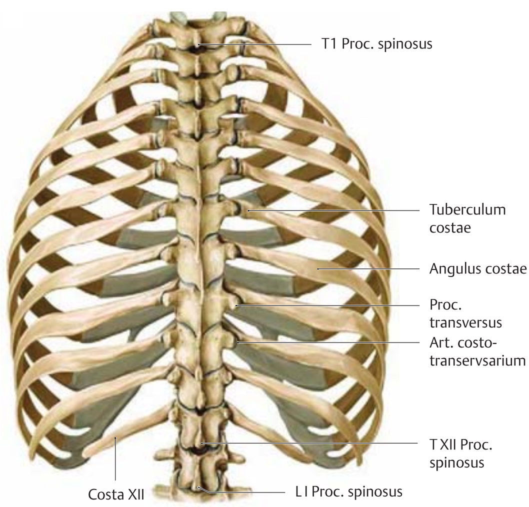
Fig. 5.1 **Thoracic skeleton**



A Anterior view.



B Left lateral view.



C Posterior view.

Fig. 5.2 **Structure of a thoracic segment**
Superior view of 6th rib pair.

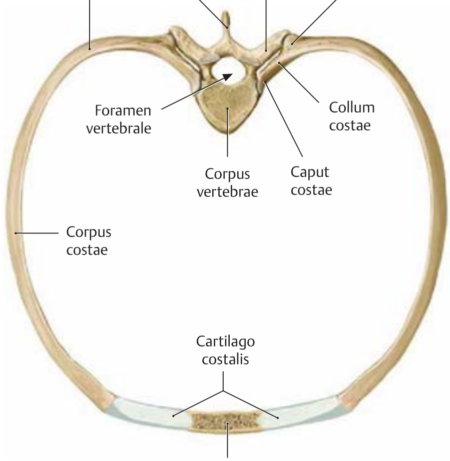
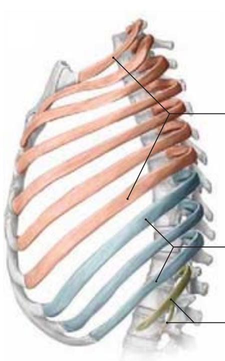


Table 5.1 **Elements of a thoracic segment**

Vertebra		
Rib	Bony part (costal bone)	Caput costae
		Collum costae
		Tuberculum costae
		Corpus costae (including angulus costae)
	Costal part (cartilago costalis)	
Sternum (articulates with cartilago costalis of costae verae only; see Fig. 5.3)		

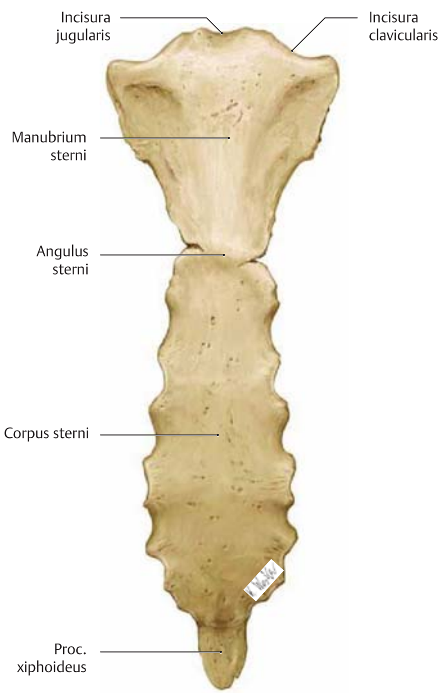
Fig. 5.3 **Types of ribs**
Left lateral view.



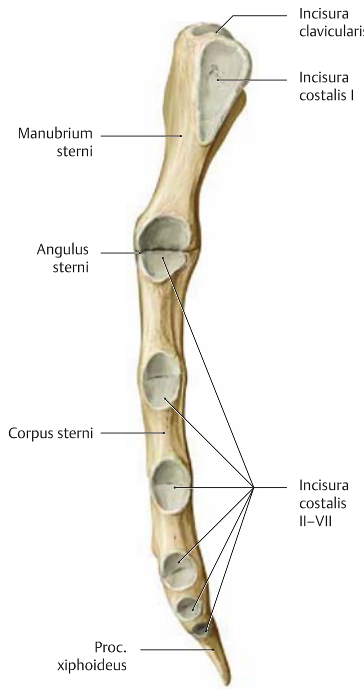
Rib type	Ribs	Anterior articulation
Costae verae	I–VII	Sternum (incisurae costales)
Costae spuriae	VIII–X	Rib above (VIII–X), None (XI, XII)
Costae fluctuantes	XI, XII	None

Sternum & Ribs

Fig. 5.4 **Sternum**
The sternum is a bladelike bone consisting of manubrium sterni, corpus sterni, and processus xiphoideus. The junction of the manubrium and corpus (angulus sterni) is typically elevated and marks the articulation of the second rib. The angulus sterni is an important landmark for internal structures.



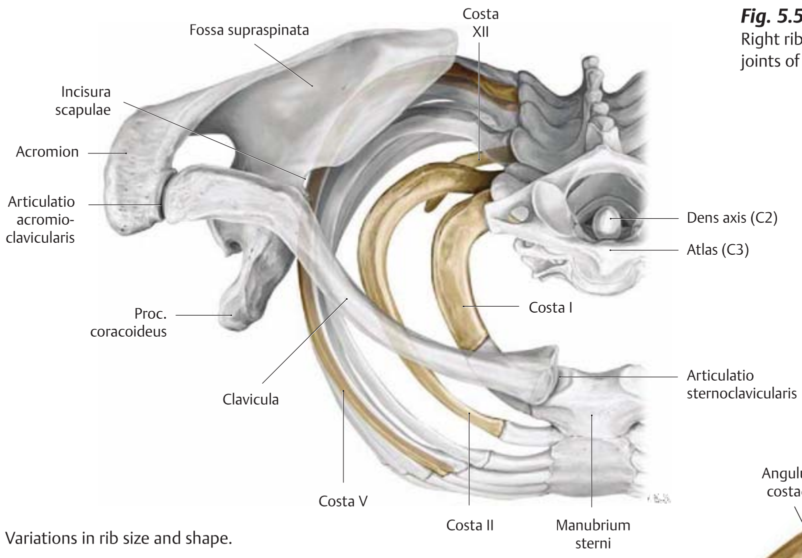
A Anterior view.



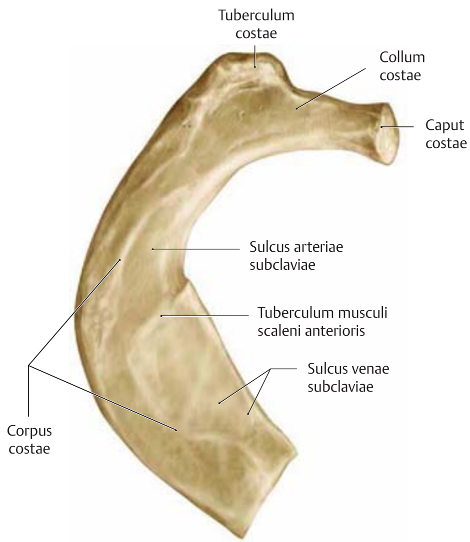
B Left lateral view. The incisurae costales are sites of articulation with the costal cartilage of the true ribs (see Fig. 5.3).

***Fig. 5.5* Costae**

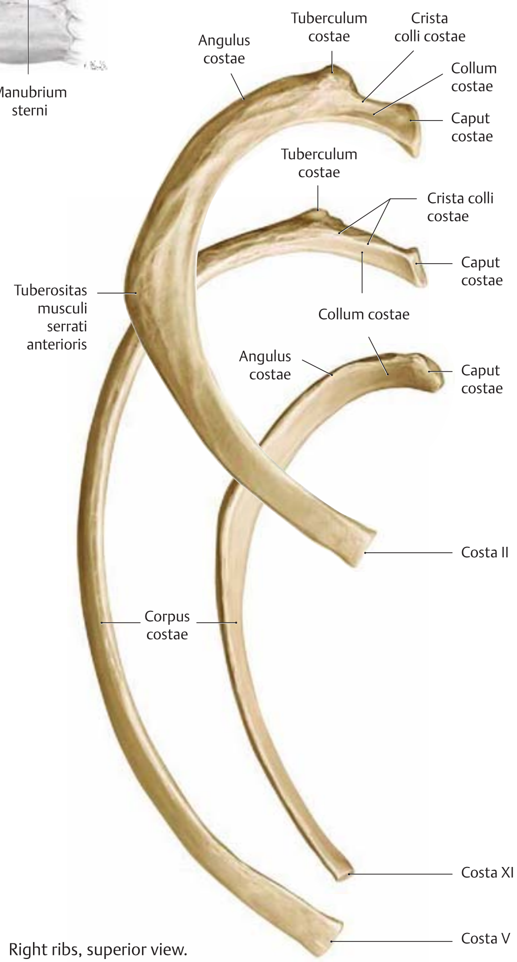
Right ribs, superior view. See pp. 258–259 for joints of the shoulder.



A Variations in rib size and shape.



B 1st rib. *Note:* Most ribs have a sulcus costae along the inferior border (not shown), which protects the intercostal vessels and nerves.

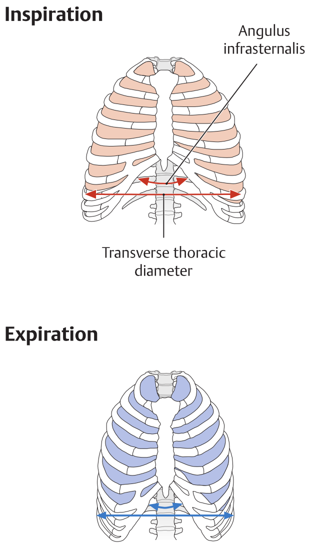


C Right ribs, superior view.

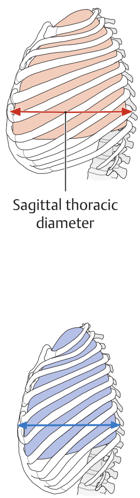
Joints of the Thoracic Cage

The diaphragma is the chief muscle for quiet respiration (see p. 52). The muscles of the thoracic wall (see p. 50) contribute to deep (forced) inspiration.

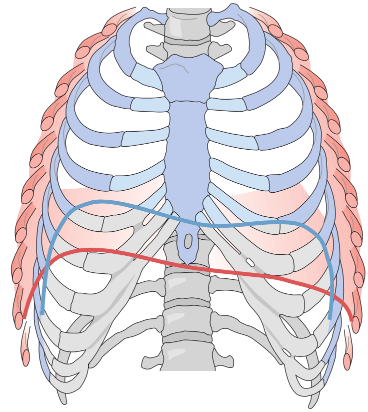
Fig. 5.6 **Rib cage movement**
Full inspiration (red); full expiration (blue). In deep inspiration, there is an increase in transverse and sagittal thoracic diameters, as well as the infrasternal angle. The descent of the diaphragm further increases the volume of the thoracic cavity.



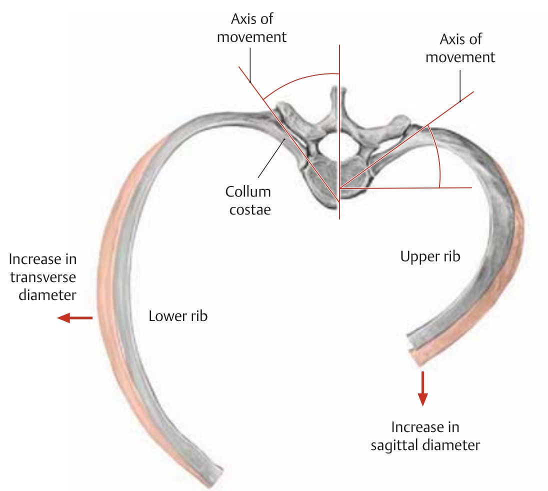
A Anterior view.



B Left lateral view.



C Position of diaphragm during respiration.



D Axes of rib movement, superior view.

Fig. 5.7 **Sternocostal joints**
Anterior view with right half of sternum sectioned frontally. True joints are generally found only at ribs 2 to 5; ribs 1, 6, and 7 attach to the sternum by synchondroses.

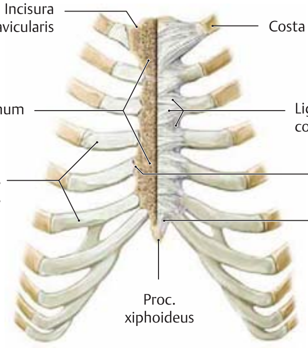
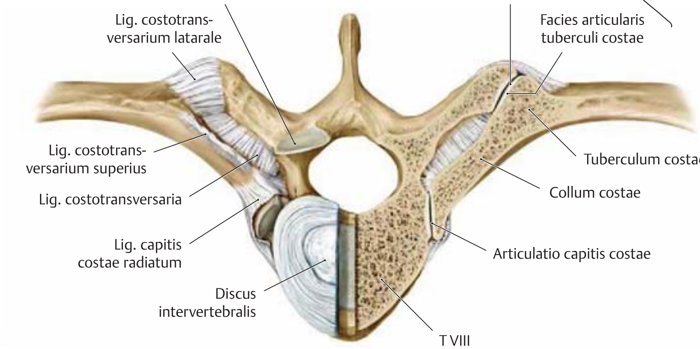
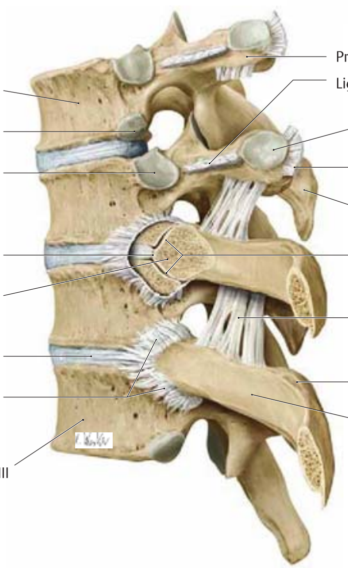


Fig. 5.8 **Costovertebral joints**
Two synovial joints make up the costovertebral articulation of each rib. The costal tubercle of each rib articulates with the costal facet of its accompanying vertebra (**A**). The head of most ribs articulates with the vertebra of its own number and the vertebra immediately superior. Ribs 1, 11, and 12 typically articulate only with their own vertebrae.



A Articulatio costotransversaria. Superior view with joints of the left rib transversely sectioned.

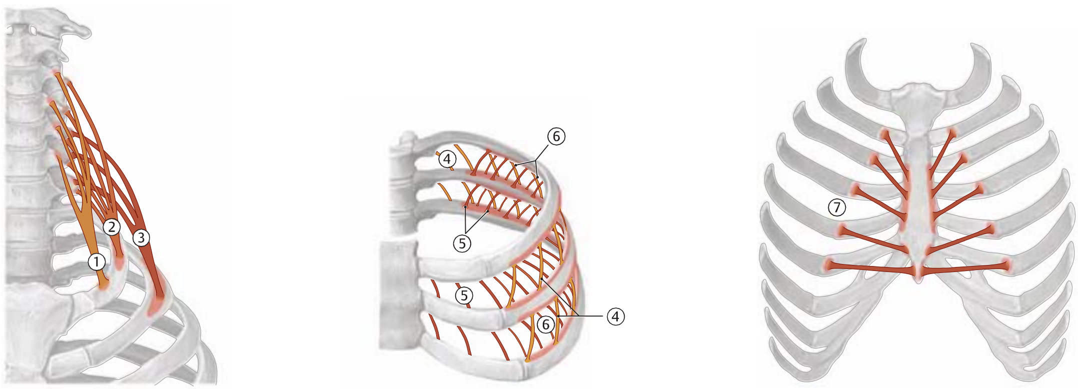


B Articulatio capitis costae. Left lateral view with the joint head of the 7th rib opened.

Thoracic Wall Muscle Facts

The muscles of the thoracic wall are primarily responsible for chest respiration, although other muscles aid in *deep* inspiration: m. pectoralis major and m. serratus anterior are discussed with the shoulder (see pp. 264–267), and m. serratus posterior is discussed with the back (see p. 30).

Fig. 5.9 **Muscles of the thoracic wall**



A Mm. scaleni, anterior view.

B Mm. intercostales, anterior view.

C M. transversus thoracis, posterior view.

Table 5.2	**Muscles of the thoracic wall**				
Muscle		**Origin**	**Insertion**	**Innervation**	**Action**
Mm. scaleni	① M. scalenus anterior	Vertebrae C III–C VI (proc. transversus, tuberculum anterius)	Costa I (Tuberculum m. scaleni anterioris)	Direct branches from cervical and brachial plexus (C3–C6)	*With ribs mobile*: Raises upper ribs (inspiration) *With ribs fixed*: Bends cervical spine to same side (unilateral); flexes neck (bilateral)
	② M. scalenus medius	Vertebrae C IV–C VI (proc. transversus, tuberculum posterius)	Costa I (posterior to sulcus arteriae subclaviae)		
	③ M. scalenus posterior		Costa II (outer surface)		
Mm. intercostales	④ M. intercostalis externus	Lower margin of rib to upper margin of next lower rib (courses obliquely forward and downward from tuberculum costae to chondro-osseous junction)		Nn. intercostales I–XI	Raises ribs (inspiration); supports intercostal spaces; stabilizes chest wall
	⑤ M. intercostalis internus	Lower margin of rib to lower margin of next lower rib (courses obliquely forward and upward from angulus costae to sternum)			Lowers ribs (expiration); supports intercostal spaces, stabilizes chest wall
	⑥ M. intercostalis intimus				
Mm. subcostales		Lower margin of lower ribs to inner surface of ribs two to three ribs below		Variable lower nn. intercostales	Raises ribs (inspiration)
⑦ M. transversus thoracis		Sternum and proc. xiphoideus (inner surface)	Costae II–VI (cartilago costalis, inner surface)	Nn. intercostales II–VII	Weakly lowers ribs (expiration)

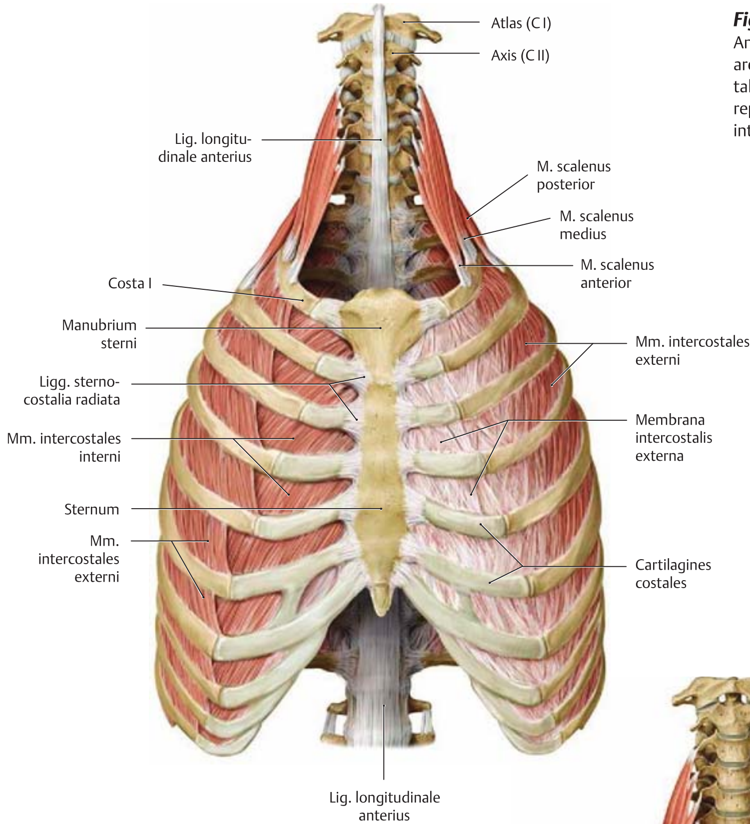
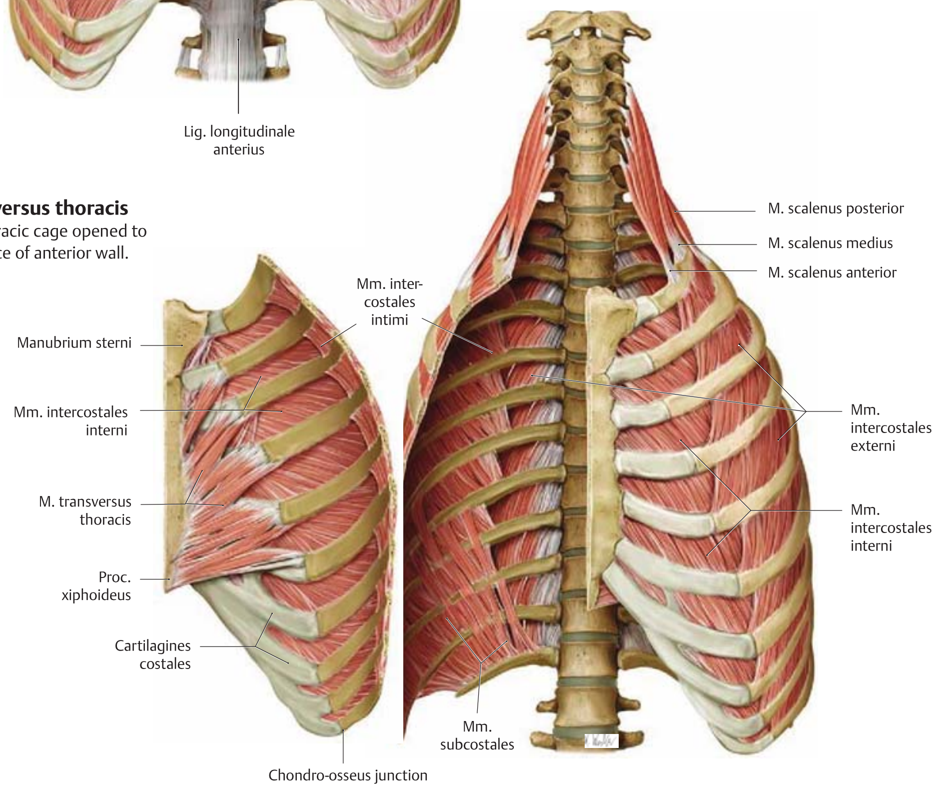


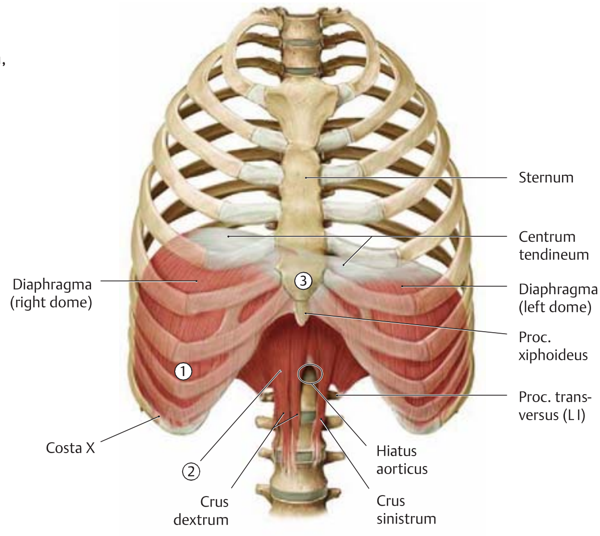
Fig. 5.10 **Muscles of the thoracic wall**
Anterior view. The mm. intercostales externi are replaced anteriorly by membrana intercostalis externa. The mm. intercostales interni are replaced posteriorly by membrana intercostalis interna (removed in Fig. 5.11).

Fig. 5.11 **M. transversus thoracis**
Anterior view with thoracic cage opened to expose posterior surface of anterior wall.

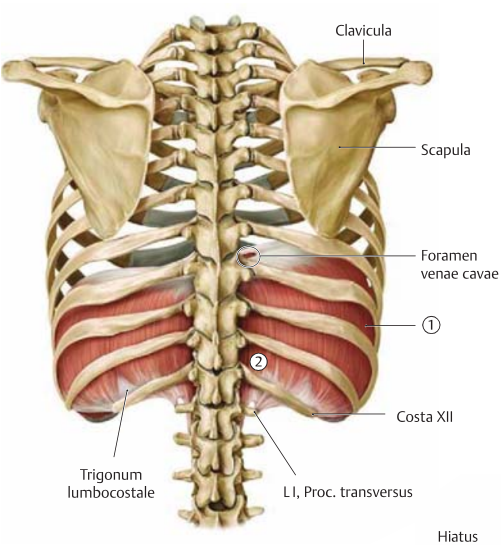


Diaphragm

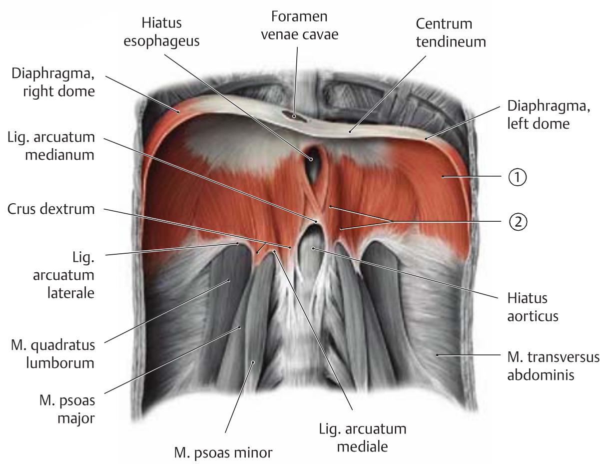
Fig. 5.12 **Diaphragma**
The diaphragma, which separates the thorax from the abdomen, has two asymmetric domes and three apertures (for the aorta, vena cava, and esophagus; see Fig. 5.13B).



A Anterior view.



B Posterior view.

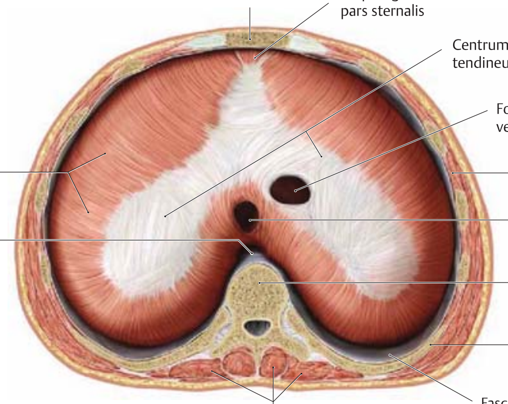


C Coronal section with diaphragma in intermediate position.

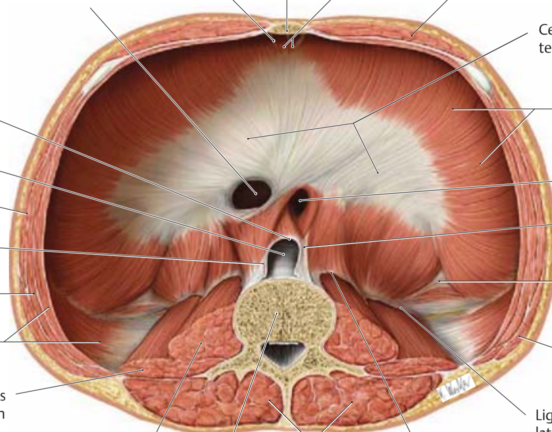
Table 5.3 Diaphragm

Muscle		Origin	Insertion	Innervation	Action
Dia-phragma	① Pars costalis diaphragmatis	Costae VII–XII (inner surface; lower margin of arcus costalis)	Centrum tendineum	N. phrenicus (C3–C5, plexus cervicalis)	Principal muscle of respiration (diaphragmatic and thoracic breathing); aids in compressing abdominal viscera (abdominal press)
	② Pars lumbalis diaphragmatis	Medial part: corpus vertebrae L I–L III, disci intervertebrales, and lig. longitudinale anterius as right and left crura			
		Lateral parts: lig. arcuatum mediale and lig. arcuatum laterale			
	③ Pars sternalis diaphragmatis	Processus xiphoideus (posterior surface)			

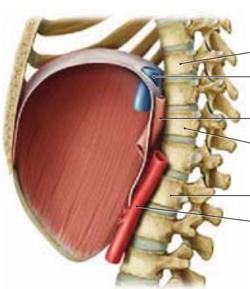
Fig. 5.13 Diaphragma in situ



A Superior view.



B Inferior view.



C Diaphragmatic apertures, left lateral view.

Neurovasculature of the Diaphragm

Fig. 5.14 **Neurovasculature of diaphragma**
Anterior view of opened thoracic cage.

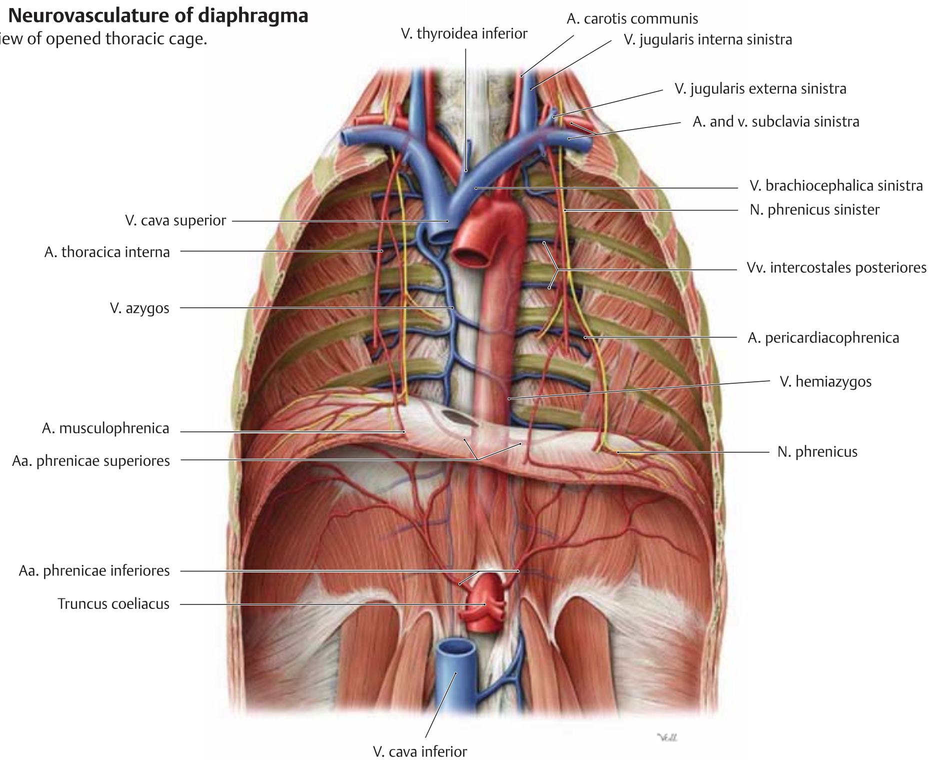


Fig. 5.15 **Innervation of the diaphragm**
Anterior view. The n. phrenicus lies on the lateral surface of the fibrous pericardium together with the pericardiacophrenic arteries and veins. *Note*: The n. phrenicus also innervates the pericardium.

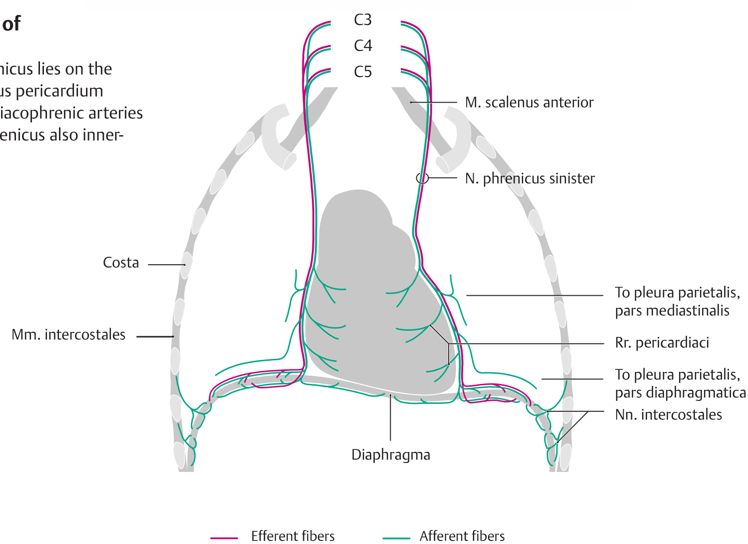
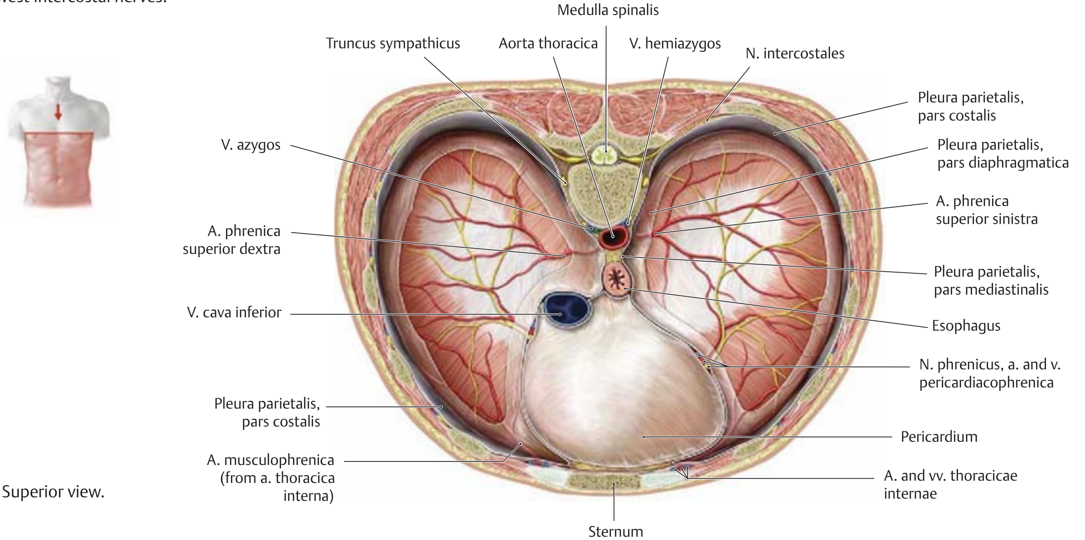


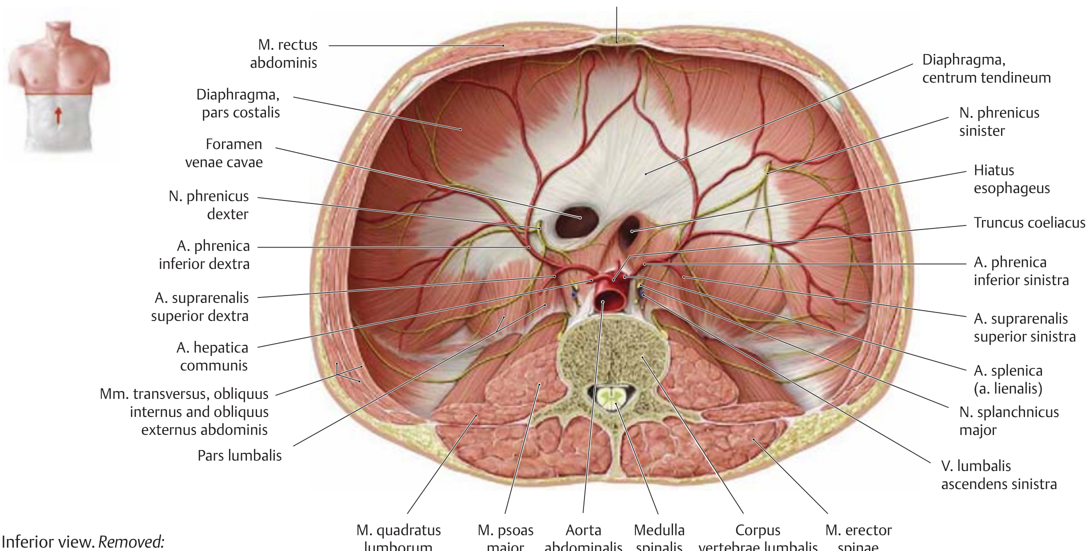
Table 5.4 Blood vessels of the diaphragm			
Artery	**Origin**	**Vein**	**Drainage**
A. phrenica inferior (chief blood supply)	Aorta abdominalis; occasionally from truncus coeliacus	Vv. intercostales posteriores	Right side: V. azygos ; Left side: V. hemiazygos
Aa. phrenicae superiores	Aorta thoracica	Vv. phrenicae superiores	
A. pericardiacophrenica	A. thoracica interna	V. intercostalis superior dextra	
A. musculophrenica			

Fig. 5.16 Arteries and nerves of diaphragma

Note: The margins of diaphragma receive sensory innervation from the lowest intercostal nerves.



A Superior view.



B Inferior view. *Removed:* Peritoneum parietale.

Arteries & Veins of the Thoracic Wall

Aa. intercostales posteriores anostomose with aa. intercostales anteriores to supply the structures of the thoracic wall. Aa. intercostales posteriores branch from aorta thoracica, with the exception of the 1st and 2nd, which arise from a. intercostalis suprema (a branch of truncus costocervicalis).

Fig. 5.17 Arteries of the thoracic wall
Anterior view.

Table 5.5 Arteries of the thoracic wall

Origin	Branch
A. subclavia and a. axillaris	A. thoracica superior
	A. thoracica lateralis
	A. thoracoacromialis
	Aa. intercostales posteriores (1st and 2nd; see p. 34)
Aorta thoracica	Aa. intercostales posteriores (3rd through 12th)
A. thoracica interna	Aa. intercostales anteriores
	A. musculophrenica
	A. epigastrica superior

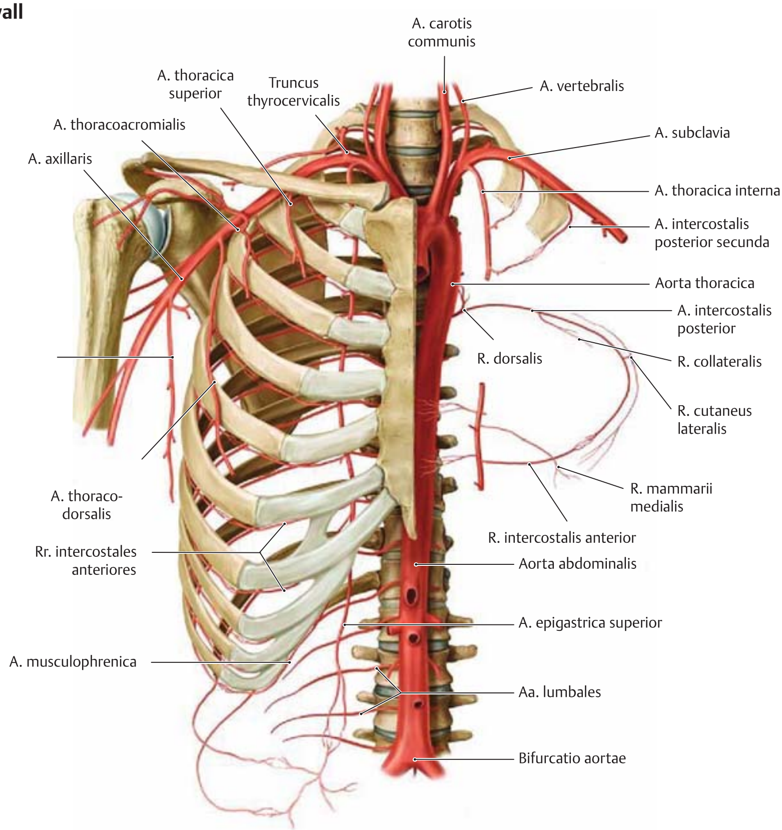


Fig. 5.18 Branches of aa. intercostales posteriores
Superior view.

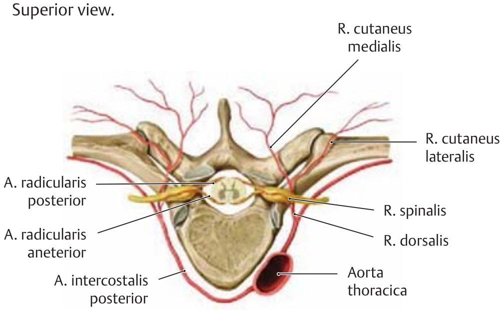


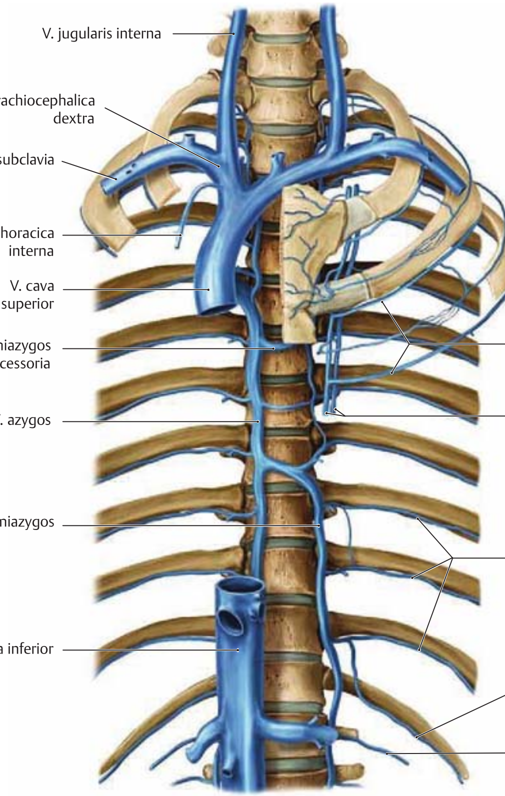
Table 5.6 Branches of the intercostal arteries

Artery	Branches		Supplies
Aa. intercostales posteriores	Ramus dorsalis	Rami spinales	Spinal cord
		Ramus cutaneus medialis	Posterior thoracic wall
		Ramus cutaneus lateralis	
	Ramus collateralis		Lateral thoracic wall
AA. intercostales anteriores	Ramus cutaneus lateralis*		Anterior thoracic wall

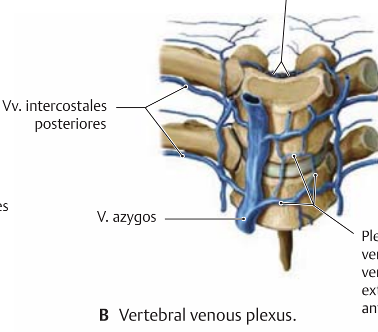
*The rami mammarii laterales from ramus cutaneus lateralis supplies the breast along with rami mammari mediales from a thoracic interna.

The vv. intercostales drain primarily into the azygos system, but also into v. thoracica interna. This blood ultimately returns to the heart via v. cava superior. The vv. intercostales follow a similar course to their arterial counterparts. However, the veins of the vertebral column form an external vertebral venous plexus that traverses the entire length of the spine (see p. 35).

Fig. 5.19 **Veins of the thoracic wall**
Anterior view.

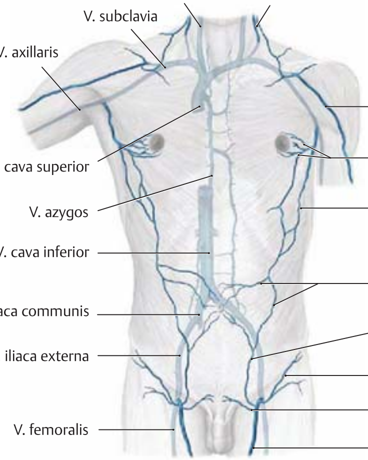


A Anterior view with rib cage opened.



B Vertebral venous plexus.

Fig. 5.20 **Superficial veins**
Anterior view. The vv. thoracoepigastricae are a potential superficial collateral venous drainage route in the event of superior or inferior vena cava obstruction.



Nerves of the Thoracic Wall

Fig. 5.21 **Nn. intercostales**
Anterior view. The 1st rib has been removed to reveal the 1st and 2nd intercostal nerves.

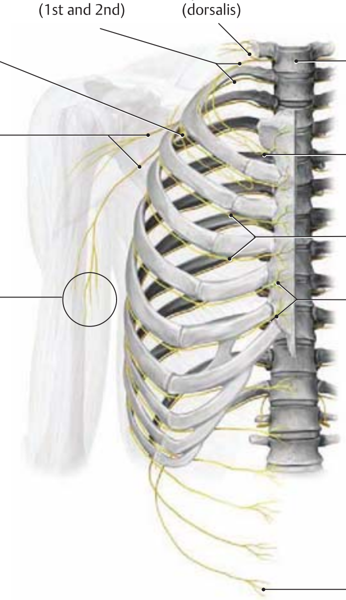
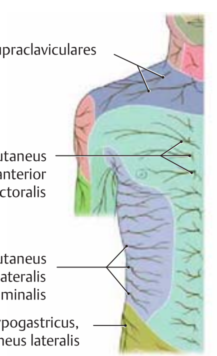
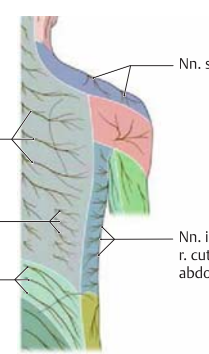


Fig. 5.22 **Thoracic wall: Peripheral sensory cutaneous innervation**



A Anterior view.



B Posterior view.

Fig. 5.23 Spinal nerve branches

Superior view. Formed by the union of the posterior (sensory) and anterior (motor) roots, the at-most 1 cm-long n. spinales courses through the intervertebral foramen and exits the vertebral canal. Its ramus posterior innervates the skin and intrinsic muscles of the back; its ramus anterior forms the nn. intercostales. See p. 36 for more details.

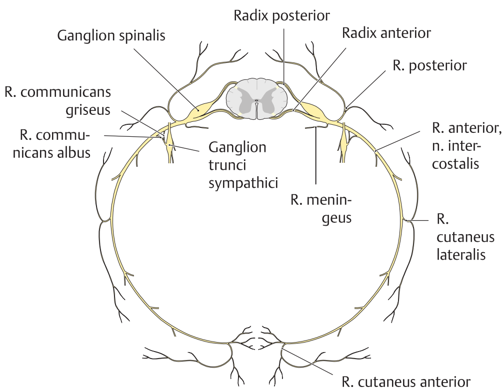


Fig. 5.24 Course of nn. intercostales

Coronal section, anterior view.

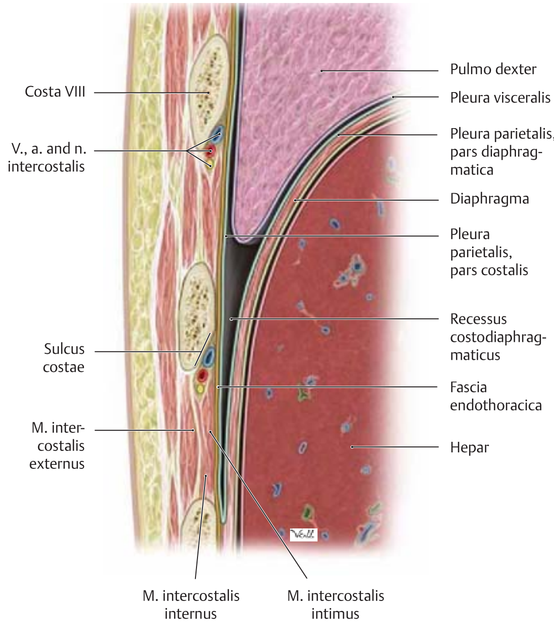


Fig. 5.25 Thoracic wall: Dermatomes

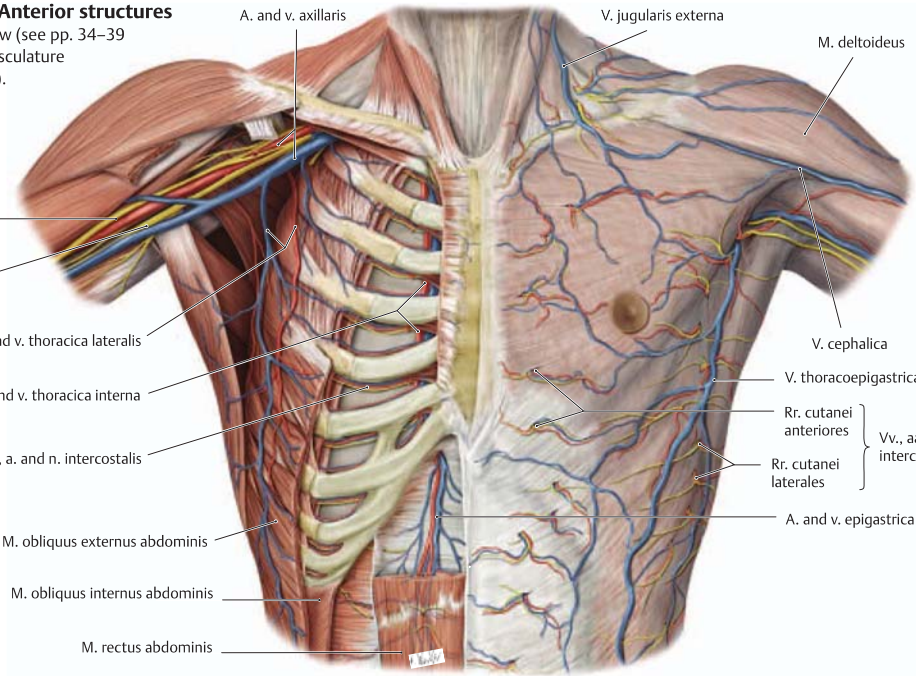
Landmarks: T4 generally includes the nipple; T6 innervates the skin over processus xiphoideus.

A Anterior view.

B Posterior view.

Neurovascular Topography of the Thoracic Wall

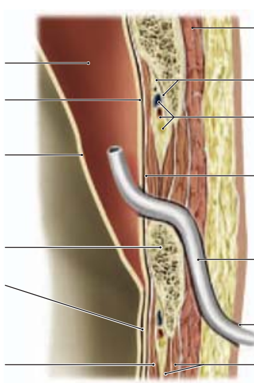
Fig. 5.26 Anterior structures
Anterior view (see pp. 34–39 for neurovasculature of the back).



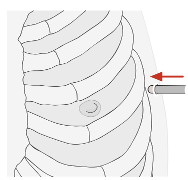
Clinical

Insertion of a chest tube

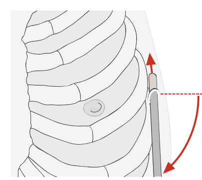
Abnormal fluid collection in the pleural space (e.g., pleural effusion due to bronchial carcinoma) may necessitate the insertion of a chest tube. Generally, the optimal puncture site in a sitting patient is at the level of the 7th or 8th intercostal space on the posterior axillary line. The drain should always be introduced at the upper margin of a rib to avoid injuring the intercostal vein, artery, and nerve. See p. 113 for details on collapsed lungs.



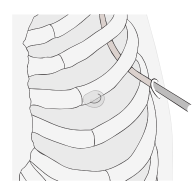
A Coronal section, anterior view.



B Drainage tube is inserted perpendicular to chest wall.

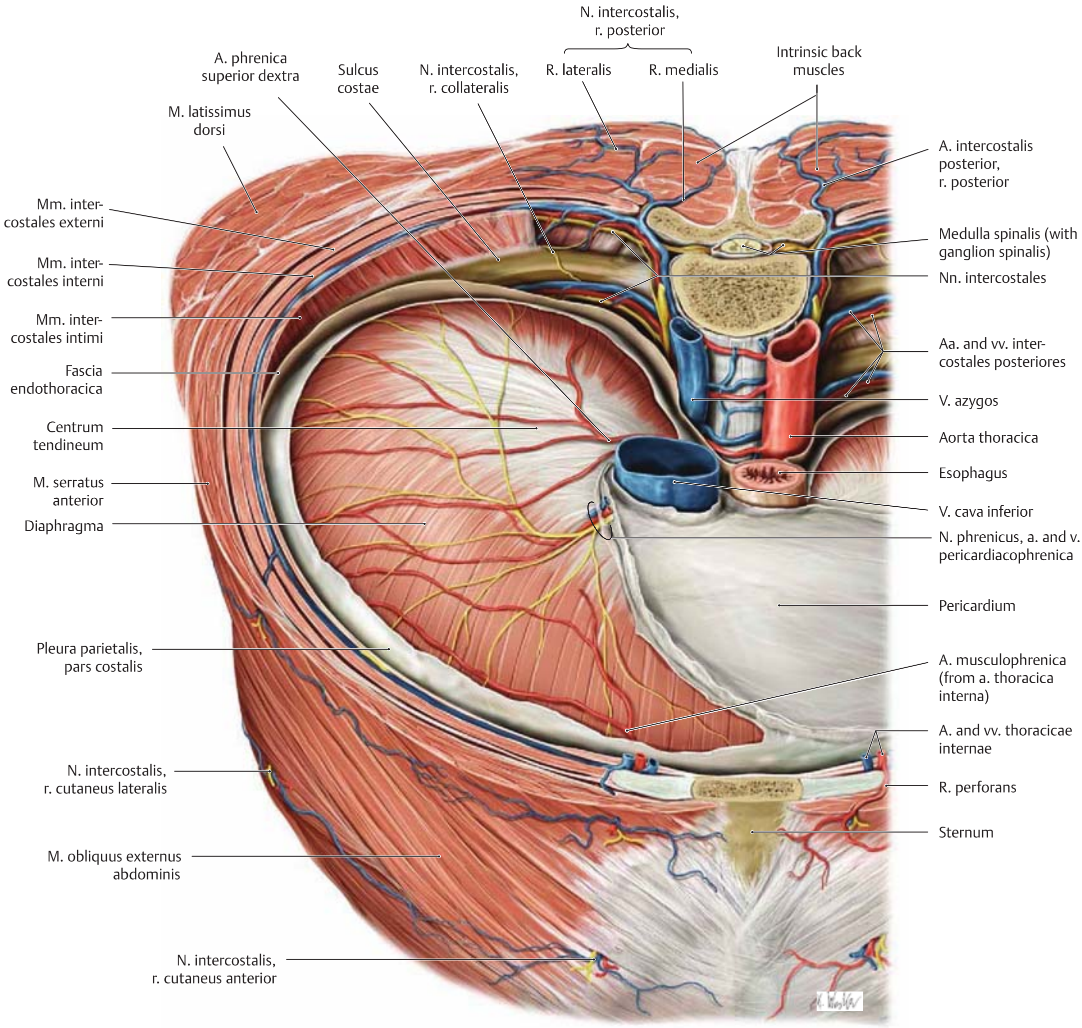


C At ribs, the tube is angled and advanced parallel to the chest wall in the subcutaneous plane.



D At the superior margin of the rib, the tube is passed through the intercostal muscles and advanced into the pleural cavity.

Fig. 5.27 **Intercostal structures in cross section**
Transverse section, anterosuperior view.



Female Breast

The female breast, a modified sweat gland in the subcutaneous tissue layer, consists of glandular tissue, fibrous stroma, and fat. The breast extends from the 2nd to the 6th rib and is loosely attached to the pectoral, axillary, and superficial abdominal fascia by connective tissue. The breast is additionally supported by suspensory ligaments. An extension of the breast tissue into the axilla, the axillary tail, is often present.

Fig. 5.28 **Female breast**
Right breast, anterior view.

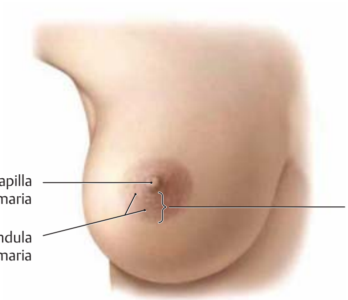


Fig. 5.29 **Mammary ridges**
Rudimentary mammary glands form in both sexes along the mammary ridges. Occasionally, these may persist in humans to form accessory nipples (*polythelia*), although only the thoracic pair normally remains.

Fig. 5.30 **Blood supply to the breast**

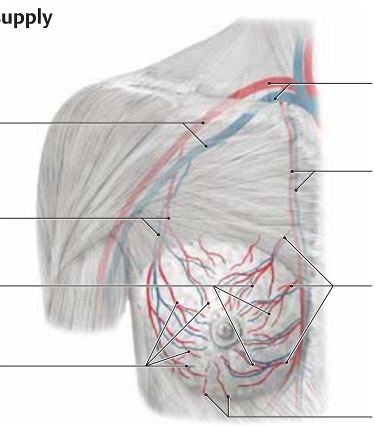
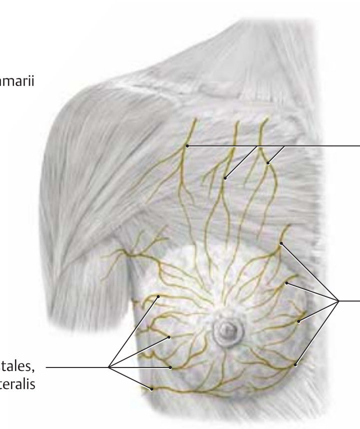
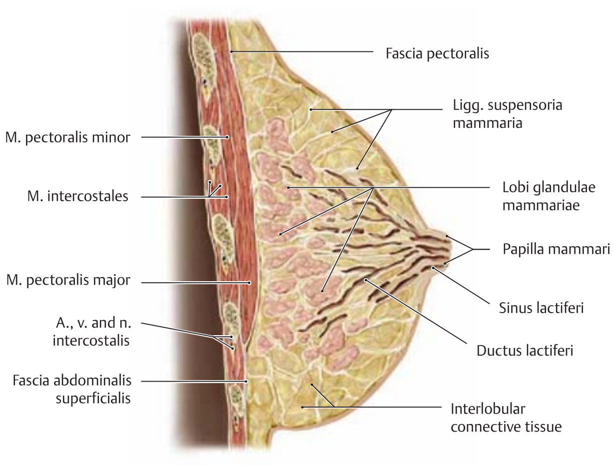


Fig. 5.31 **Sensory innervation of the breast**

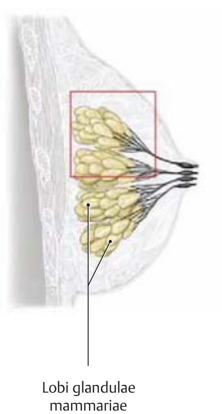


The glandular tissue is composed of 10 to 20 individual lobes, each with its own ductus lactiferi. The gland ducts open on the elevated papilla mammaria at the center of the pigmented areola mammae. Just proximal to the duct opening is a dilated portion called the sinus lactiferi. Areolar elevations are the openings of the areolar glands (sebaceous). The glands and lactiferous ducts are surrounded by firm, fibrofatty tissue with a rich blood supply.

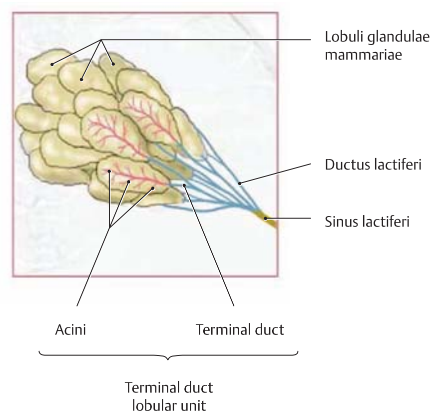
Fig. 5.32 Structures of the breast



A Sagittal section along midclavicular line.



B Duct system and portions of a lobe, sagittal section. In the nonlactating breast (shown here), the lobules contain clusters of rudimentary acini.

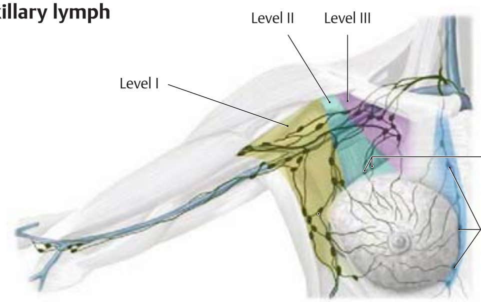


C Terminal duct lobular unit (TDLU). The clustered acini composing the lobule empty into a terminal ductule; these structures are collectively known as the TDLU.

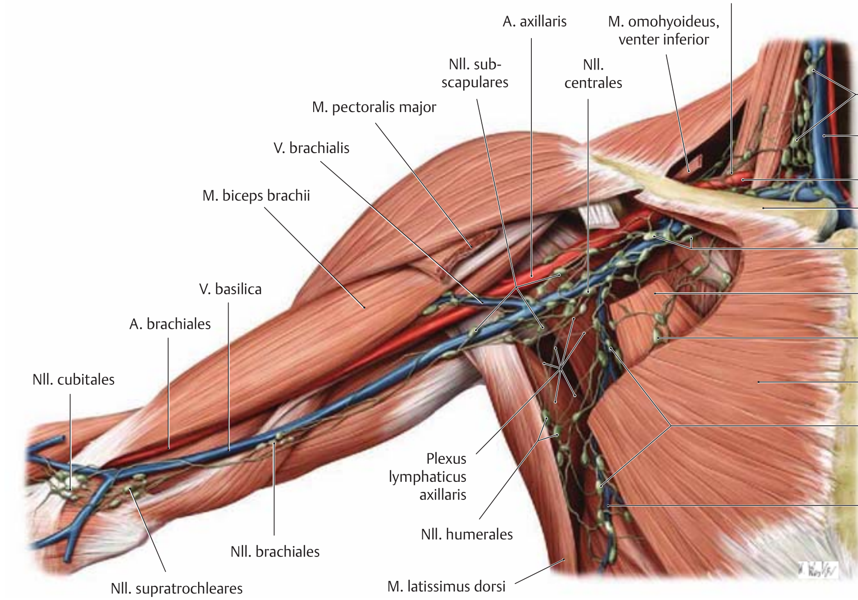
Lymphatics of the Female Breast

The lymphatic vessels of the breast (not shown) are divided into three systems: superficial, subcutaneous, and deep. These drain primarily into the nll. axillares, which are classified based on their relationship to the pectoralis minor (Table 5.7). The medial portion of the breast is drained by nll. parasternales, which are associated with the internal thoracic vessels.

Fig. 5.33 **Axillary lymph nodes**



A Lymphatic drainage of the breast.



B Anterior view.

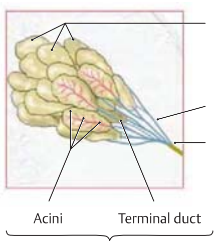
Table 5.7 **Levels of axillary lymph nodes**

Level		Position	Lymph nodes (Nll.)
I	Lower axillary group	Lateral to m. pectoralis minor	Nll. pectorales/anteriores
			Nll. subscapulares/posteriores
			Nll. humerales/laterales
			Nll. centrales
II	Middle axillary group	Along m. pectoralis minor	Nll. interpectorales
III	Upper infraclavicular group	Medial to m. pectoralis minor	Nll. apicales

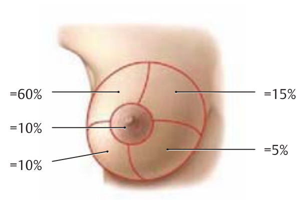
Clinical

Breast cancer

Stem cells in the intralobular connective tissue give rise to tremendous cell growth, necessary for duct system proliferation and acini differentiation. This makes the terminal duct lobular unit (TDLU) the most common site of origin of malignant breast tumors.



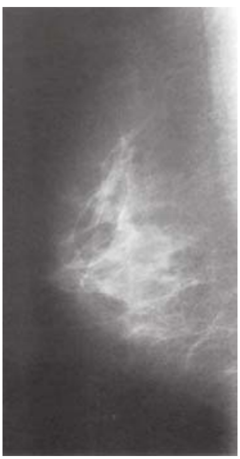
A Terminal duct lobular unit.



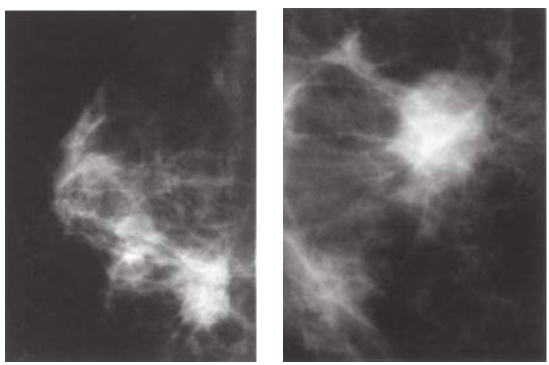
B Origin of malignant tumors by quadrant.

Tumors originating in the breast spread via the lymphatic vessels. The deep system of lymphatic drainage (level III) is of particular importance, although the parasternal lymph nodes provide a route by which tumor cells may spread across the midline. The survival rate in breast cancer correlates most strongly with the number of lymph nodes involved at the axillary nodal level. Metastatic involvement is gauged through scintigraphic mapping with radiolabeled colloids (technetium [Tc] 99m sulfur microcolloid). The downstream sentinel node is the first to receive lymphatic drainage from the tumor and is therefore the first to be visualized with radiolabeling. Once identified, it can then be removed (via *sentinel lymphadenectomy*) and histologically examined for tumor cells. This method is 98% accurate in predicting the level of axillary nodal involvement.

Metastatic involvement	5-year survival rate
Level I	65%
Level II	31%
Level III	~0%



C Normal mammogram.

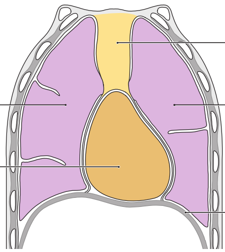


D Mammogram of invasive ductal carcinoma. The large lesion has changed the architecture of the neighboring breast tissue.

Divisions of the Thoracic Cavity

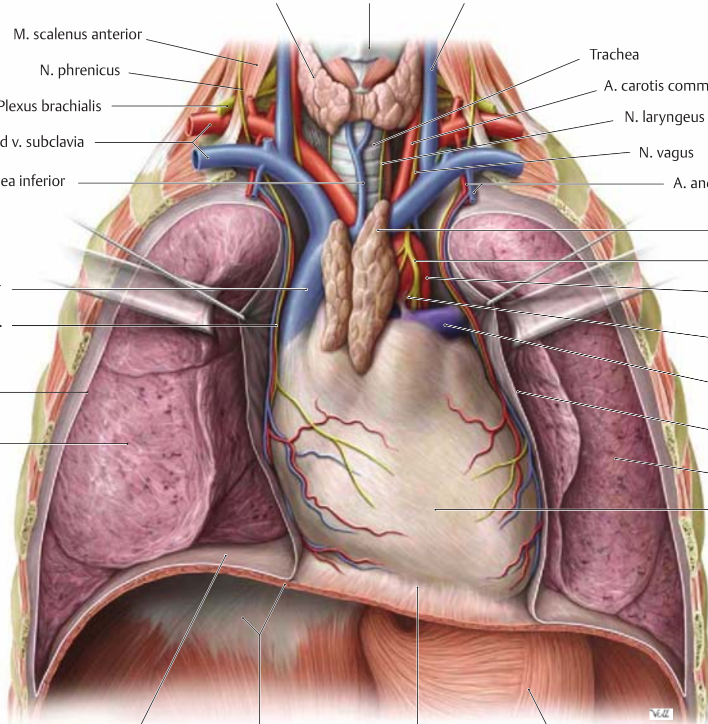
The thoracic cavity is divided into three large spaces: the mediastinum (p. 76) and the two pleural cavities (p. 102).

Fig. 6.1 Thoracic cavity
Coronal section, anterior view.



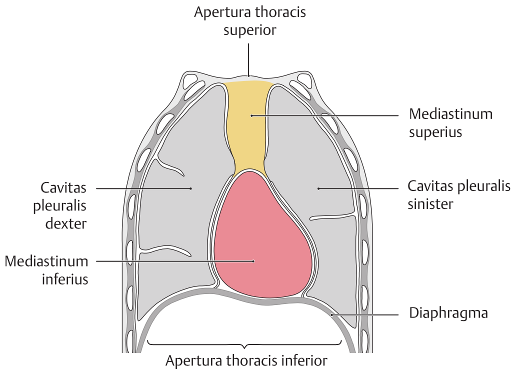
A Divisions of the thoracic cavity.

Table 6.1	Major structures of the thoracic cavity		
Mediastinum	Mediastinum superius		Thymus, great vessels, trachea, esophagus, and ductus thoracicus
	Mediastinum inferius	Mediastinum anterius	Thymus
		Mediastinum medium	Cor, pericardium, and roots of great vessels
		Mediastinum posterius	Aorta thoracica, ductus thoracicus, esophagus, and azygos venous system
Cavitas pleuralis	Cavitas pleuralis dexter		Pulmo dexter
	Cavitas pleuralis sinister		Pulmo sinister

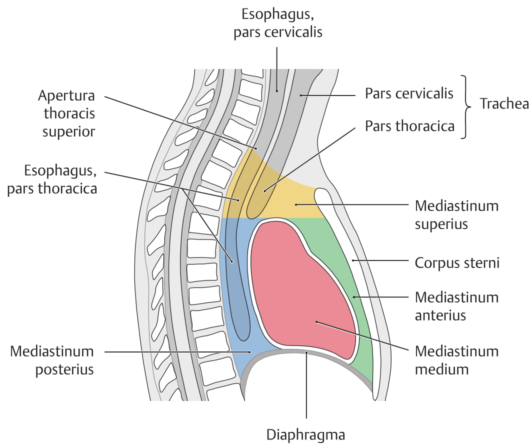


B Opened thoracic cavity. *Removed:* Thoracic wall; connective tissue of anterior mediastinum.

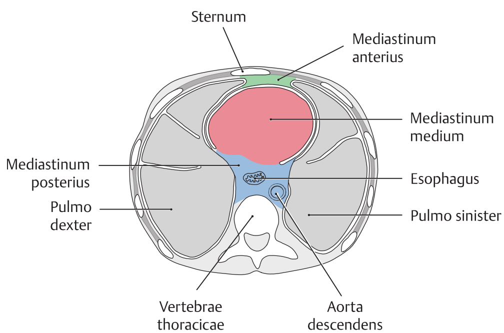
Fig. 6.2 **Divisions of the mediastinum**



A Anterior view (coronal section).



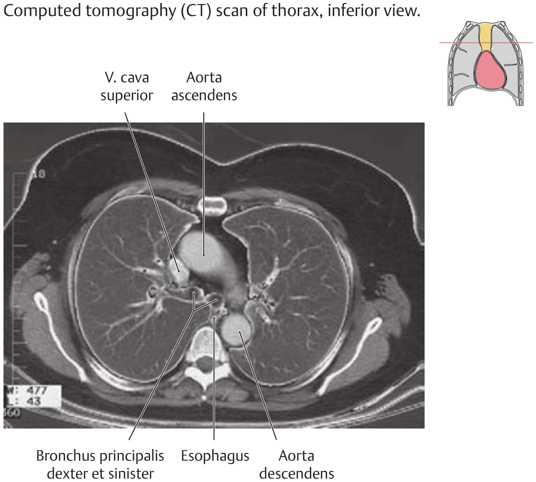
B Lateral view (midsagittal section).



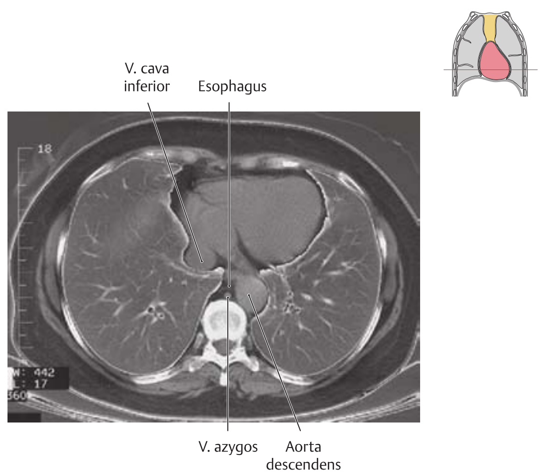
C Inferior view (transverse section).

Fig. 6.3 **Transverse sections of the thorax**

Computed tomography (CT) scan of thorax, inferior view.



A Mediastinum superius.

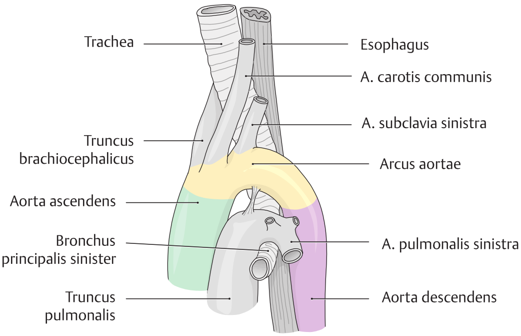


B Mediastinum inferius.

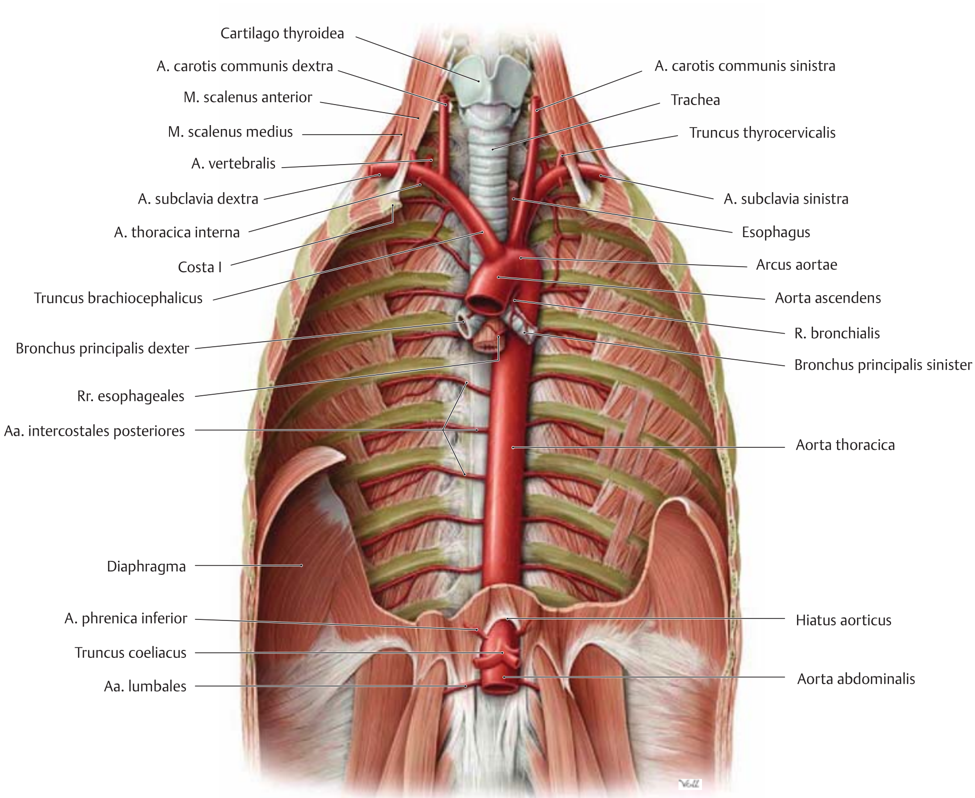
Arteries of the Thoracic Cavity

The arcus aortae has three major branches: truncus brachiocephalicus, a. carotis communis sinistra, and a. subclavia sinistra. After arcus aortae, the aorta begins its descent, becoming aorta thoracica at the level of angulus sterni and aorta abdominalis once it passes through hiatus aorticus in the diaphragm.

Fig. 6.4 **Thoracic aorta**



A Parts of the aorta, left lateral view. *Note:* The arcus aortae begins and ends at the level of angulus sterni (see p. 46).



B Aorta thoracica in situ, anterior view. *Removed:* Heart, lungs, portions of diaphragma.

Table 6.2 Branches of the thoracic aorta

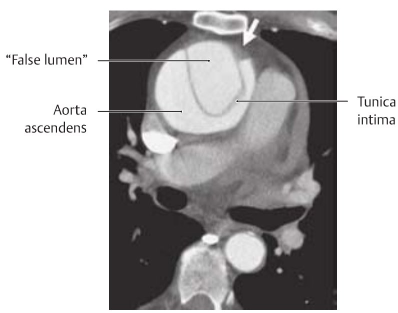
The thoracic organs are supplied by direct branches from aorta thoracica, as well as indirect branches from aa. subclaviae.

Branches			Region supplied
Truncus brachiocephalicus	A. subclavia dextra		See a. subclavia sinistra
	A. carotis communis dextra		Head and neck
A. carotis communis sinistra			
A. subclavia sinistra	A. vertebralis		
	A. thoracica interna	Aa. intercostales anteriores	Anterior chest wall
		Rr. thymici	Thymus
		Rr. mediastinales	Mediastinum posterius
		A. pericardiacophrenica	Pericardium, diaphragma
	Truncus thyrocervicalis	A. thyroida inferior	Esophagus, trachea, gl. thyroida
	Truncus costocervicalis	A. intercostalis suprema	Chest wall
Aorta thoracica, pars descendens	Visceral branches		Cor, pericardium, bronchi, trachea, esophagus
	Parietal branches	Aa. intercostales posteriores	Posterior chest wall
		Aa. phrenicae superiores	Diaphragma

Clinical

Aortic dissection

A tear in the inner wall (intima) of the aorta allows blood to separate the layers of the aortic wall, creating a "false lumen" and potentially resulting in life-threatening aortic rupture. Symptoms are dyspnea (shortness of breath) and sudden onset of excruciating pain. Acute aortic dissections occur most often in the ascending aorta and generally require surgery. More distal aortic dissections may be treated conservatively, provided there are no complications (e.g., obstruction of blood supply to the organs, in which case a stent may be inserted to restore perfusion). Aortic dissections occurring at the base of a coronary artery may cause myocardial infarction.



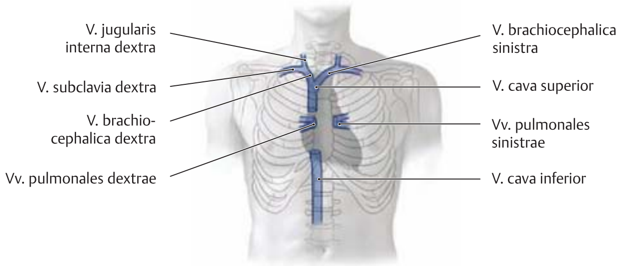
A Aortic dissection. Parts of the intima are still attached to the connective tissue in the wall of the aorta (*arrow*).

B The flow in the coronary arteries is intact (*arrow*).

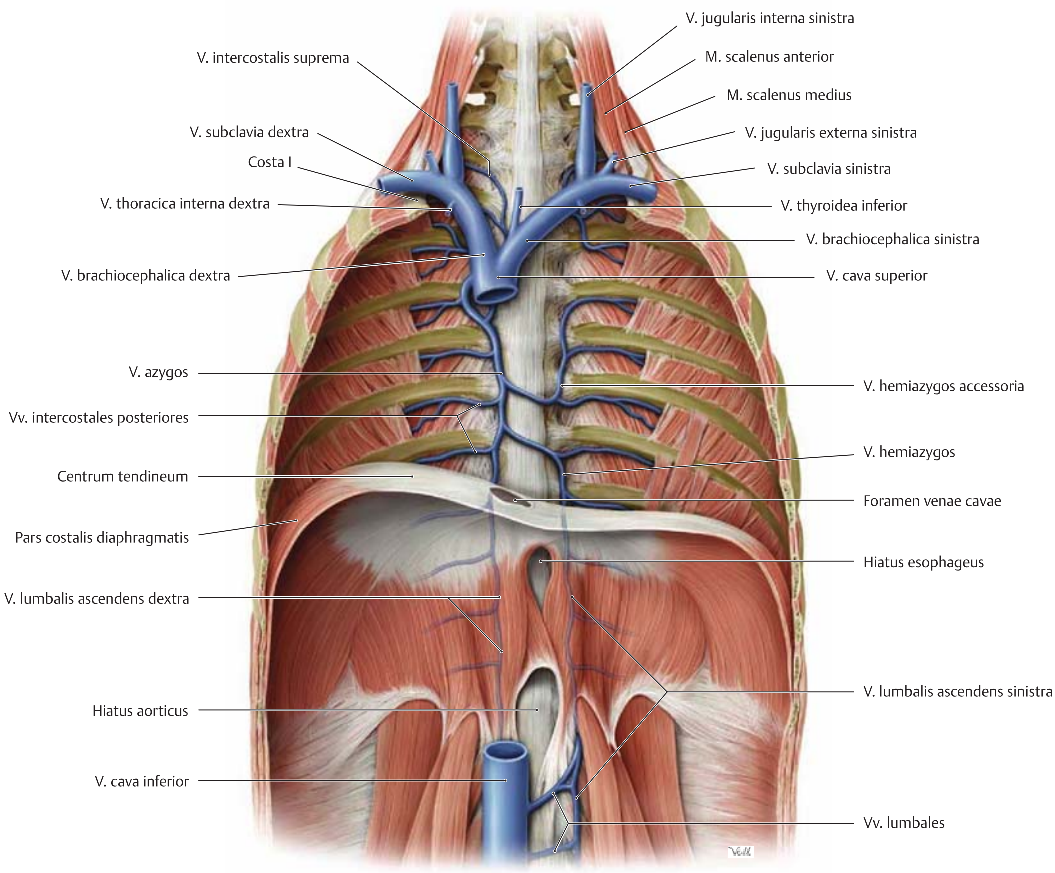
Veins of the Thoracic Cavity

The v. cava superior is formed by the union of the two vv. brachiocephalicae at the level of the T II–T III junction. It receives blood drained by the azygos system (v. cava inferior has no tributaries in the thorax).

Fig. 6.5 **V. cava superior and azygos system**



A Projection of venae cavae onto chest, anterior view.



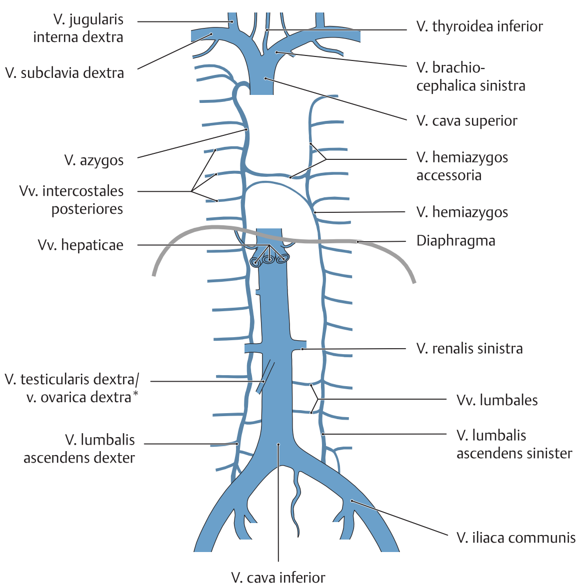
B Veins of the thoracic cavity, anterior view of opened thorax.

Table 6.3 Thoracic tributaries of the superior vena cava

Major vein	Tributaries		Region drained
Vv. brachiocephalicae	V. thyroidea inferior		Esophagus, trachea, gl. thyroidea
	V. jugularis interna		Head, neck, upper limb
	V. jugularis externa		
	V. subclavia		
	V. intercostalis suprema		
	Vv. pericardiacae		
	V. intercostalis superior sinistra		
Azygos system (left side: v. hemiazygos and v. hemiazygos accessoria; right side: v. azygos)	Visceral branches		Trachea, bronchi, esophagus
	Parietal branches	Vv. intercostales posteriores	Inner chest wall and diaphragm
		Vv. phrenicae superiores	
		V. intercostalis superior dextra	
Vv. thoracicae internae	Vv. thymicae		Thymus
	Vv. mediastinales		Mediastinum posterius
	Vv. intercostales anteriores		Anterior chest wall
	Vv. pericardiacophrenicae		Pericardium
	Vv. musculophrenicae		Diaphragma

Note: Structures of the mediastinum superius may also drain directly to vv. brachiocephalicae via vv. tracheales, vv. esophageales and vv. mediastinales.

Fig. 6.6 **Azygos system**
Anterior view.



*V. testicularis/ovarica sin. arises from v. renalis sin.

Lymphatics of the Thoracic Cavity

The body's chief lymph vessel is ductus thoracicus. Beginning in the abdomen at the level of L I as the *cisterna chyli*, the ductus thoracicus empties into the junction of v. jugularis interna sinistra and v. subclavia sinistra. The ductus lymphaticus dexter drains to the junction of v. jugularis interna dextra and v. subclavia dextra.

Fig. 6.7 **Lymphatic trunks in the thorax**
Anterior view of opened thorax.

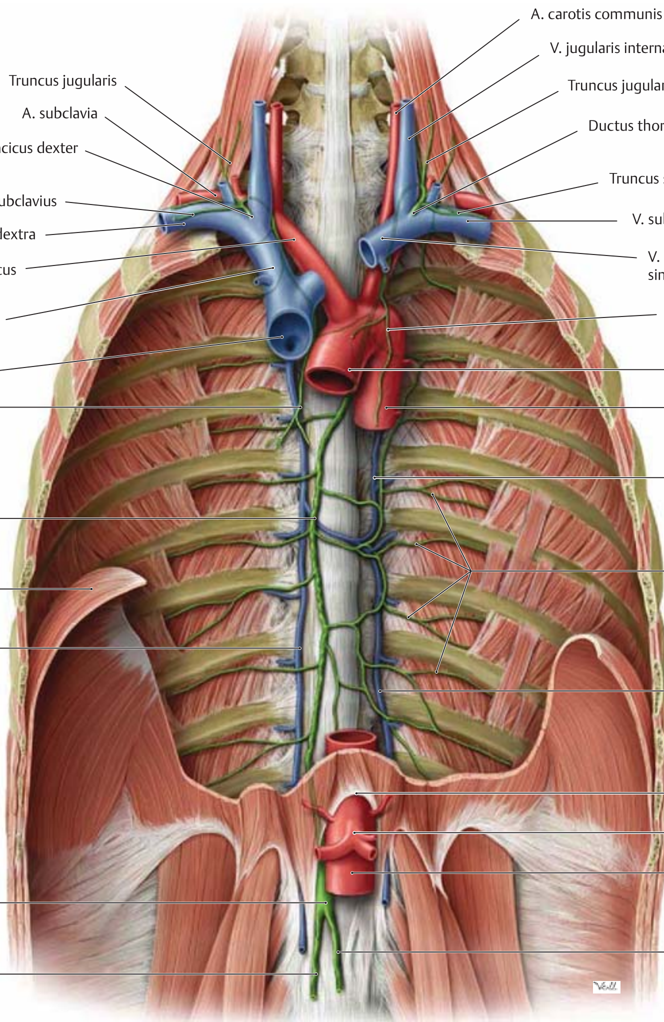


Fig. 6.8 Lymphatic pathways in the thorax

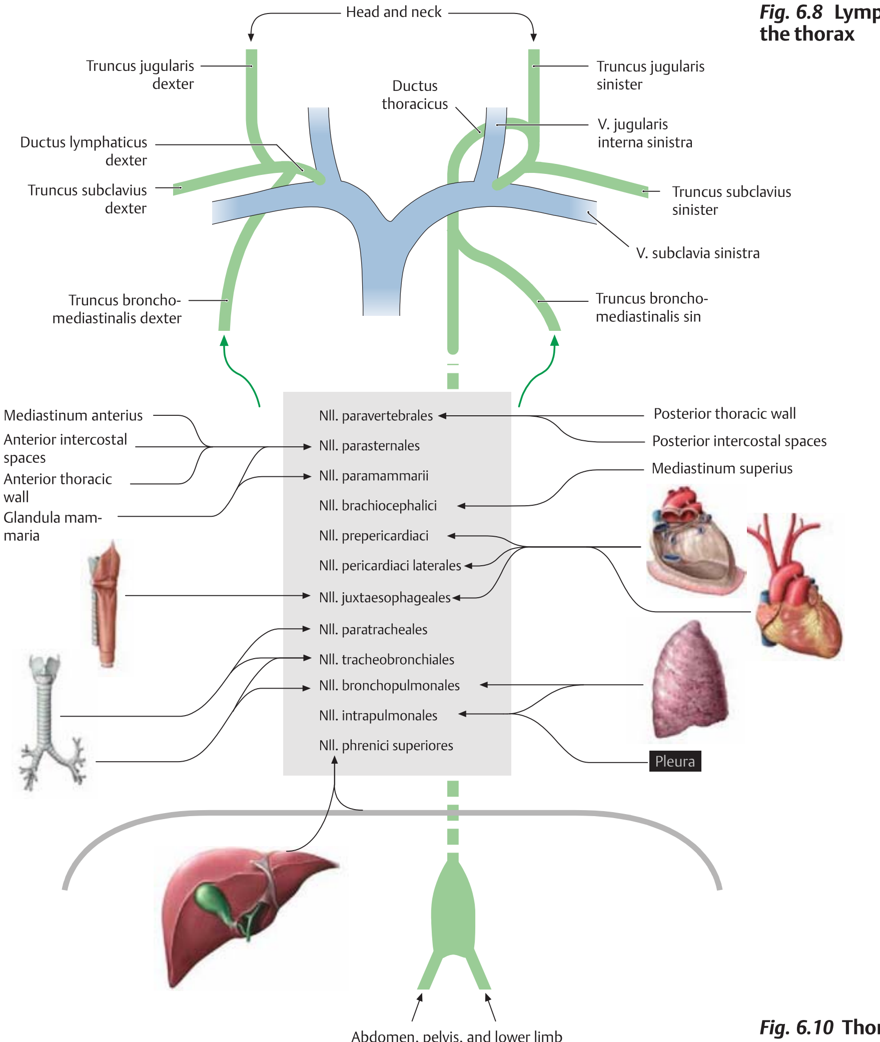
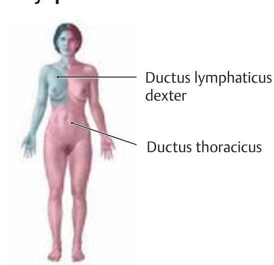


Fig. 6.9 Lymphatic drainage by quadrants



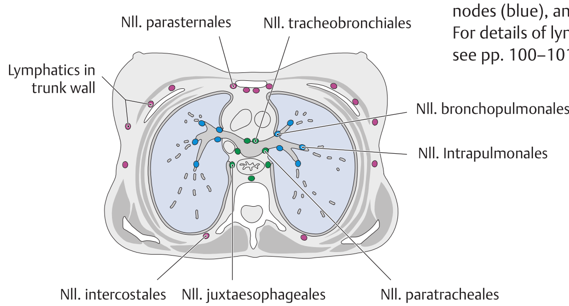
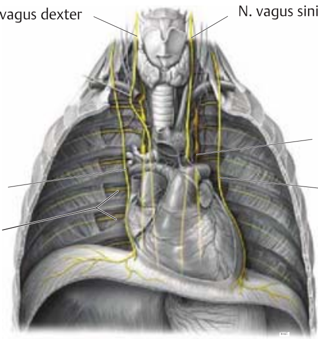


Fig. 6.10 Thoracic lymph nodes
Transverse section at level of tracheal bifurcation (T IV), inferior view. The thoracic lymph nodes can be divided into three broad groups: nodes of the thoracic wall (pink), pulmonary nodes (blue), and mediastinal nodes (green). For details of lymphatics of the mediastinum, see pp. 100–101.

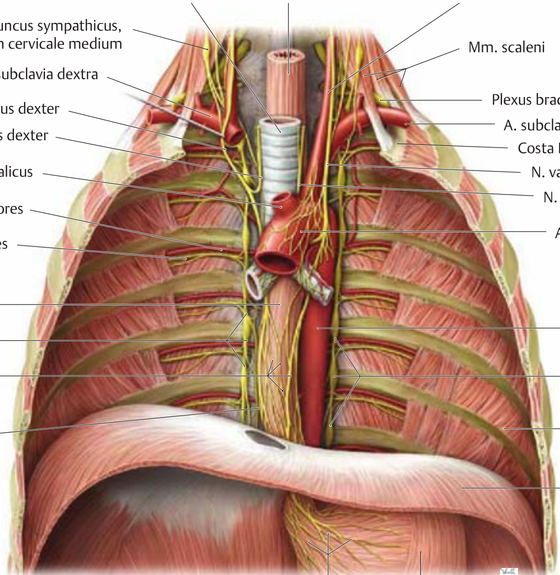
Nerves of the Thoracic Cavity

Thoracic innervation is mostly autonomic, arising from the paravertebral sympathetic trunks and parasympathetic vagus nerves. There are two exceptions: the phrenic nerves innervate the pericardium and diaphragm (p. 54), and the intercostal nerves innervate the thoracic wall (p. 58).

Fig. 6.11 **Nerves in the thorax**
Anterior view of opened thorax.



A Thoracic innervation.



B Nerves of the thorax in situ. *Note:* The recurrent laryngeal nerves have been slightly anteriorly retracted; normally, they occupy the groove between the trachea and the esophagus, making them vulnerable during thyroid gland surgery.

The autonomic nervous system innervates smooth muscle, cardiac muscle, and glands. It is subdivided into the sympathetic (red) and parasympathetic (blue) nervous systems, which together regulates blood flow, secretions, and organ function.

Fig. 6.12 **Sympatheticand parasympathetic nervous systems in the thorax**

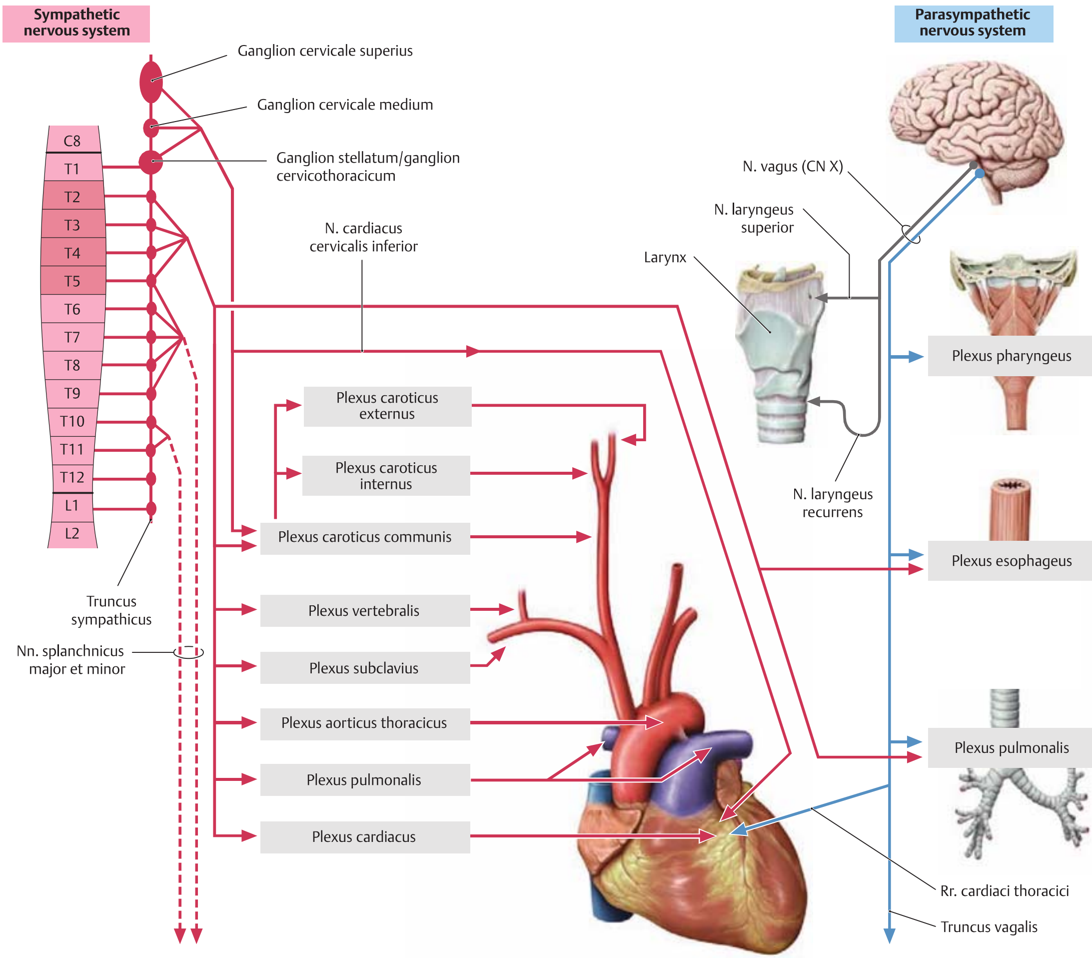


Table 6.4	**Peripheral sympathetic nervous system**		
Origin of presynaptic fibers*	**Ganglion cells**	**Course of postsynaptic fibers**	**Target**
Spinal cord	Truncus sympathicus	Follow nn. intercostales	Blood vessels and glands in chest wall
		Accompany intrathoracic aa.	Visceral targets
		Gather in n. splanchnicus major and n. splanchnicus minor	Abdomen

*The axons of presynaptic neurons exit the spinal cord via the anterior roots and synapse with *post*synaptic neurons in the sympathetic ganglia.

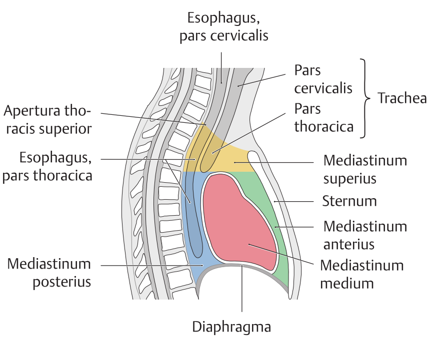
Table 6.5	**Peripheral parasympathetic nervous system**		
Origin of presynaptic fibers	**Course of presynaptic motor axons***		**Target**
Brainstem	N. vagus (CN X)	Rr. cardiaci	Plexus cardiacus
		Rr. esophagei	Plexus esophageus
		Rr. tracheales	Trachea
		Rr. bronchiales	Plexus pulmonalis (bronchi, pulmonary vessels)

*The ganglion cells of the parasympathetic nervous system are scattered in microscopic groups in their target organs. The n. vagus thus carries the *pre*synaptic motor axons to these targets.
CN = cranial nerve.

Mediastinum: Overview

The mediastinum is the space in the thorax between the pleural sacs of the lungs. It is divided into two parts: superior and inferior. The inferior mediastinum is further divided into anterior, middle, and posterior portions.

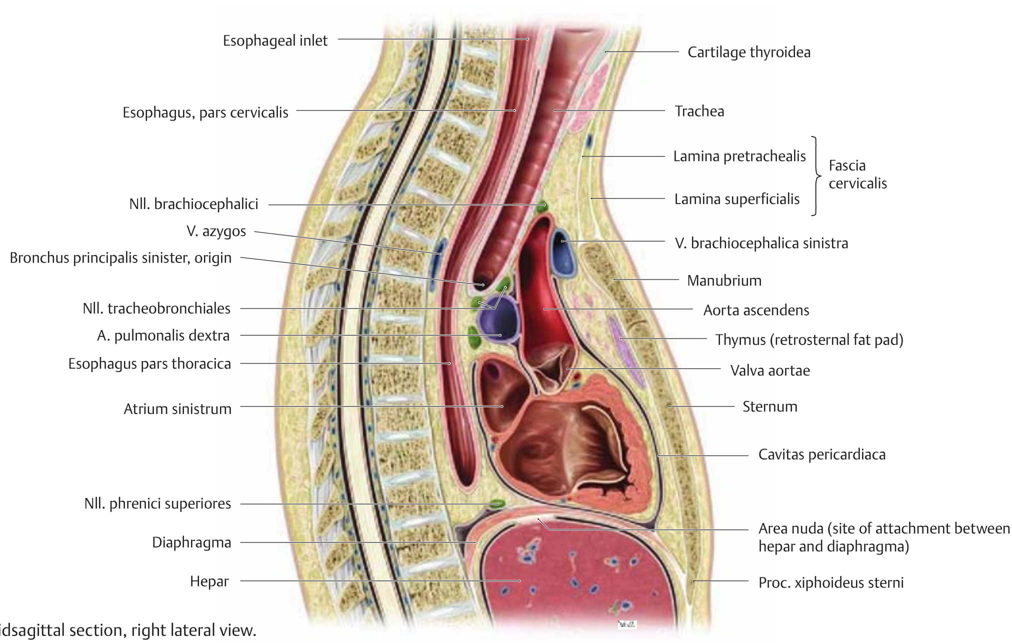
Fig. 7.1 Divisions of the mediastinum



A Schematic.

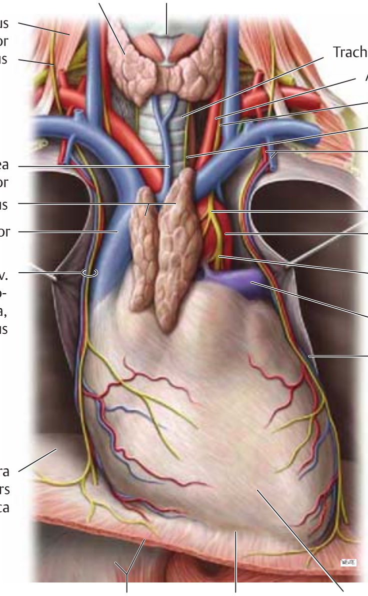
Table 7.1 Contents of the mediastinum

	Mediastinum superius	Mediastinum inferius		
		Mediastinum anterius	*Mediastinum medium*	*Mediastinum posterius*
Organs	• Thymus • Trachea • Esophagus • Ductus thoracicus	• Thymus (in children, see Fig. 7.5)	• Heart • Pericardium	• Esophagus
Arteries	• Arcus aortae • Truncus brachiocephalicus • A. carotis communis sinistra • A. subclavia sinistra	• Smaller vessels	• Aorta ascendens • Truncus pulmonalis and aa. pulmonales • Aa. and vv. pericardiacophrenicae	• Aorta thoracica and branches • Ductus thoracicus
Veins and lymph vessels	• V. cava superior • Vv. brachiocephalicae • Ductus thoracicus	• Smaller vessels, lymphatics, and lymph nodes	• V. cava superior • V. azygos • Vv. pulmonales • Aa. and vv. pericardiacophrenicae	• V. azygos • V. hemiazygos • Ductus thoracicus
Nerves	• Nn. vagi • N. laryngeus recurrens sinister • Cardiac nerves • Nn. phrenici	• None	• Nn. phrenici	• Nn. vagi

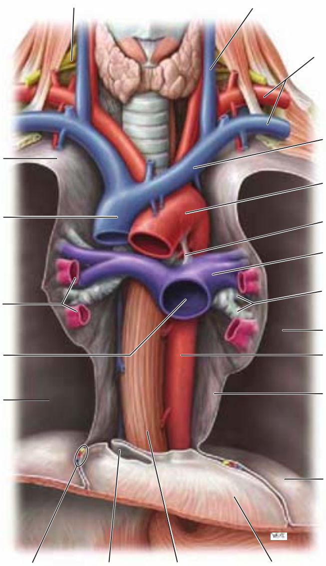


B Midsagittal section, right lateral view.

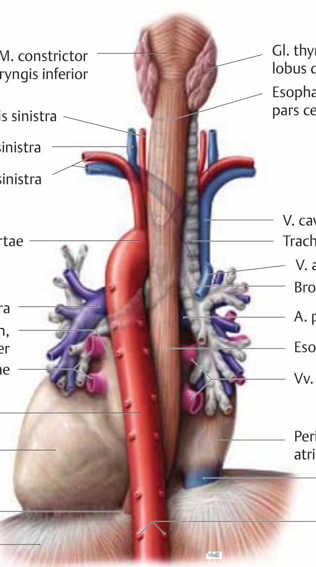
Fig. 7.2 **Contents of the mediastinum**



A Anterior view of mediastinum.



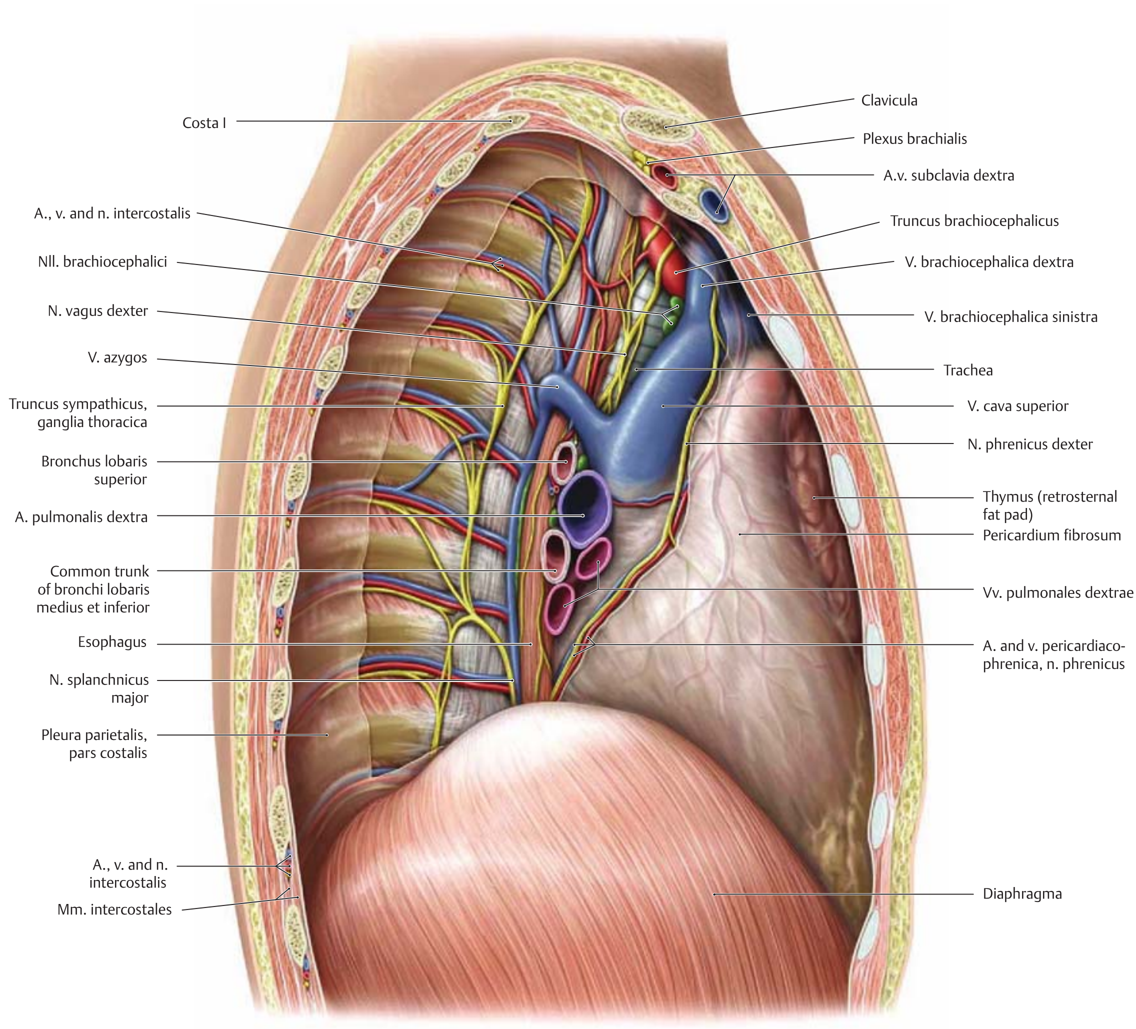
B Anterior view with heart, pericardium, and thymus removed.



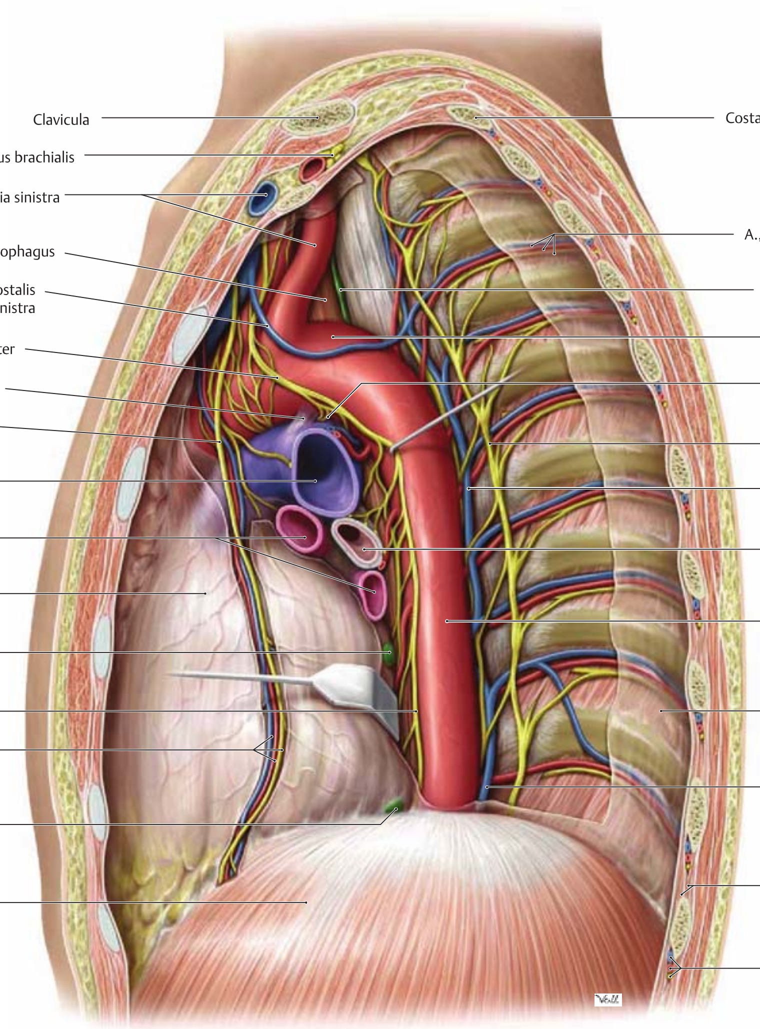
C Posterior view.

Mediastinum: Structures

Fig. 7.3 **Mediastinum**



A Right lateral view, parasagittal section. Note the many structures passing between the superior and inferior (middle and posterior) mediastinum.



B Left lateral view, parasagittal section. *Removed:* Left lung and pleura parietale. *Revealed:* Posterior mediastinal structures.

Thymus & Pericardium

Fig. 7.4 **Thymus and pericardium in situ**
Anterior view of coronal section. The thymus lies in the superior mediastinum.

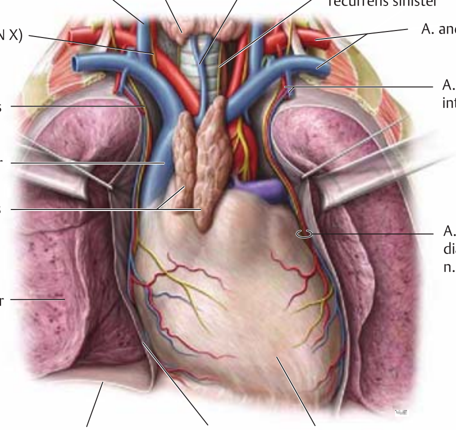


Fig. 7.5 **Thymus**
Anterior view of opened thorax of a 2-year-old child. The thymus is well developed at this age, extending inferiorly into the anterior mediastinum (compare with Fig. 7.4). The thymus grows throughout childhood; at puberty, high levels of circulating sex hormones cause the thymus to atrophy.

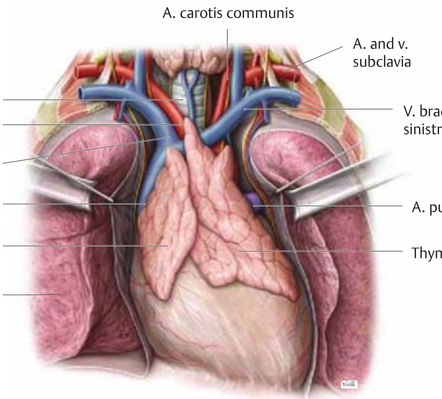


Fig. 7.6 **Pericardium**
Anterior view of opened thorax with flaps of pericardium fibrosum reflected.

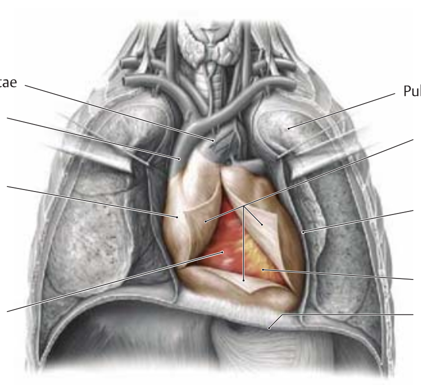
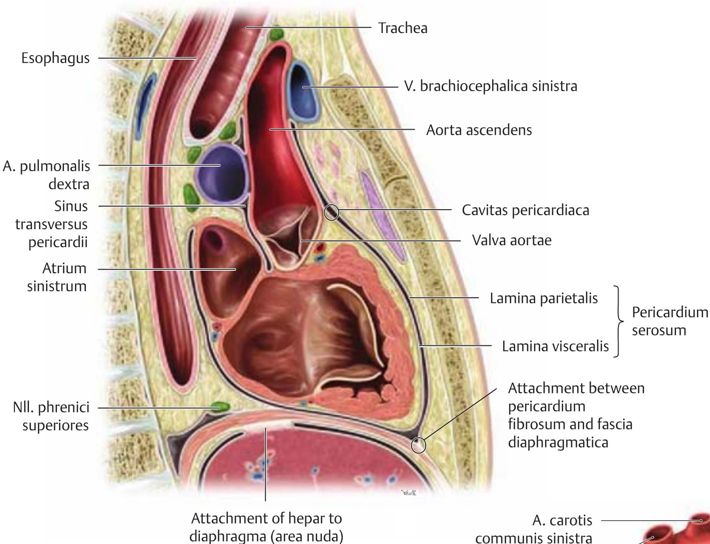
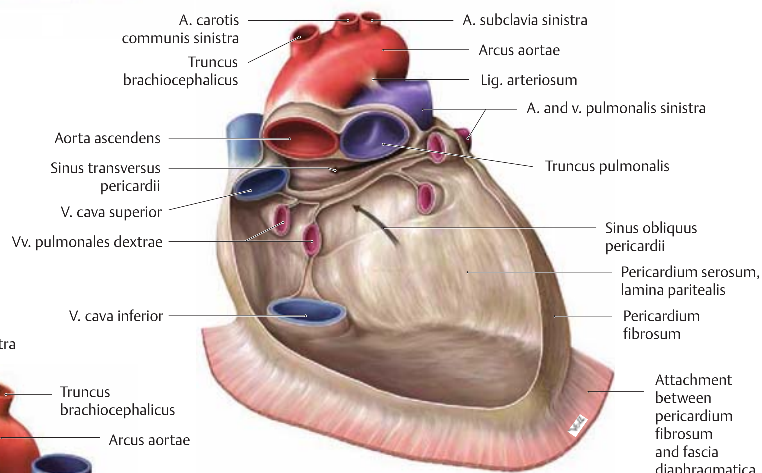


Fig. 7.7 Reflections of pericardium serosum

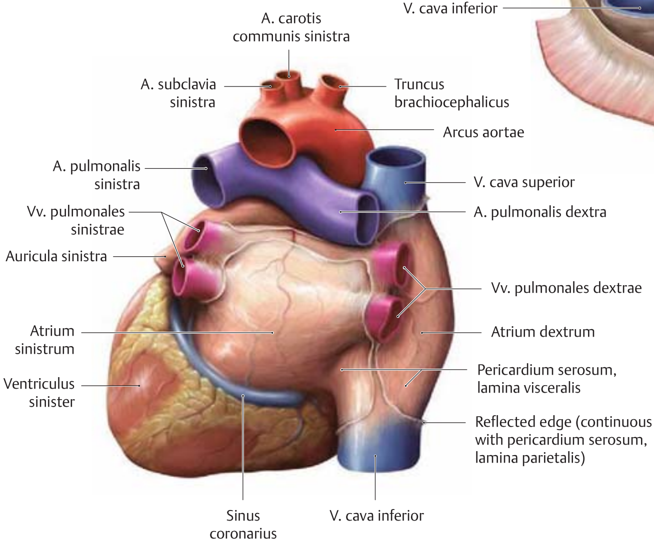
Anterior view. The lamina parietalis and lamina visceralis (epicardium) of the pericardium serosum are continuous with one another around the great vessels of the heart. The passage between the arterial- and venous-associated reflections is the sinus transversus pericardii (see **B**).



A Sagittal section through the mediastinum. Note the continuity of the lamina parietalis and lamina visceralis (epicardium) of the pericardium serosum.



B Pericardium with heart removed, anterior view.

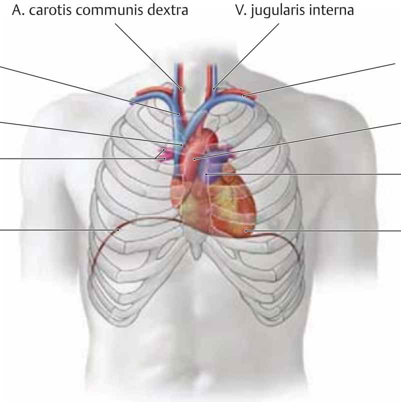


C Heart removed from pericardium fibrosum, posterior view. Note the reflection of the epicardium (cut edges).

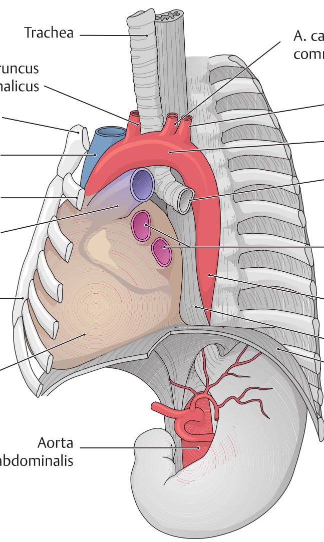
Heart in Situ

The heart is located posterior to the sternum in the middle portion of the inferior mediastinum. The heart projects into the left side of the thoracic cavity.

Fig. 7.8 **Topographical relations of the heart**



A Projection of heart and great vessels onto chest, anterior view.



B Left lateral view.

Fig. 7.9 **Circulation**

Red: Oxygenated blood. Blue: Deoxygenated blood. See p. 94 for prenatal circulation.

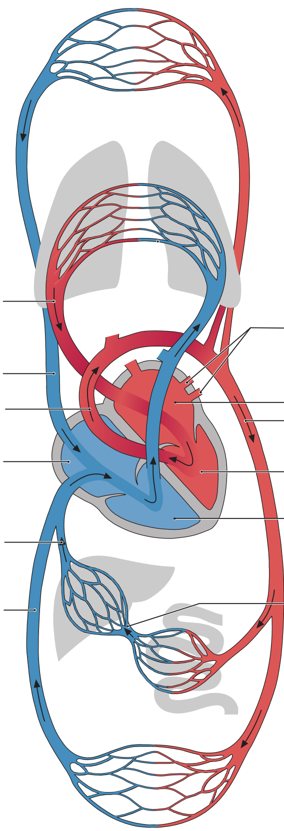
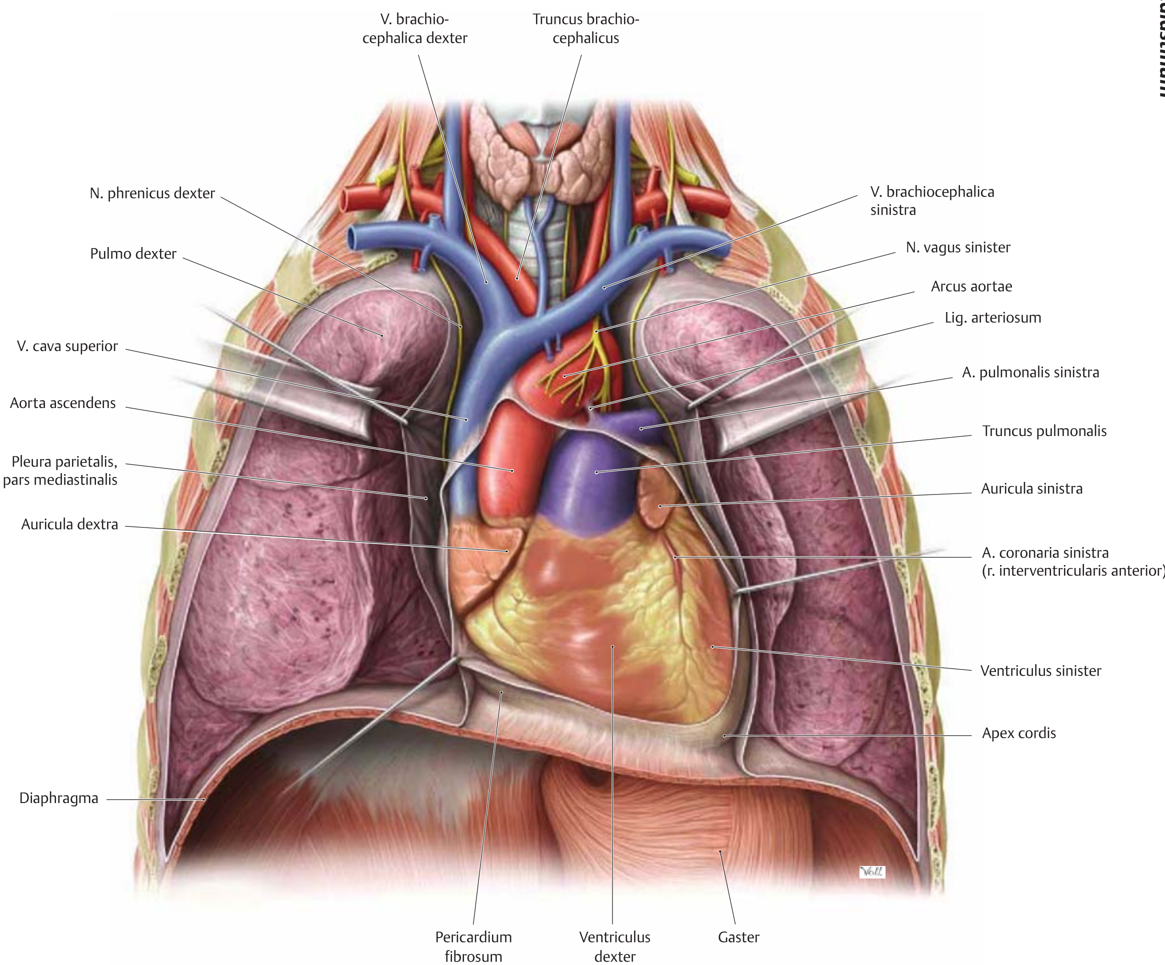


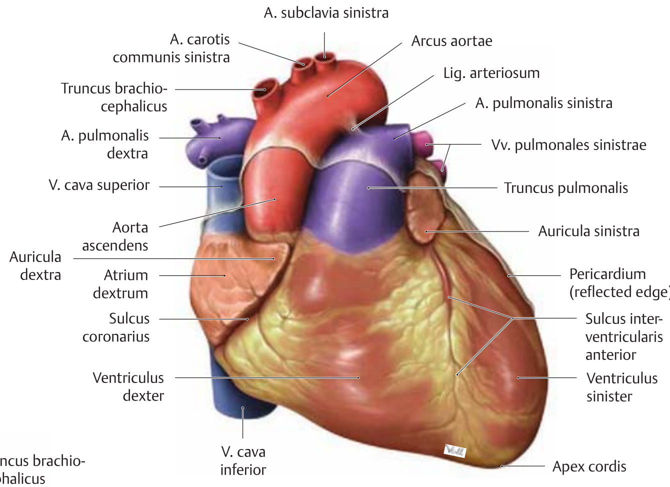
***Fig. 7.10* Heart in situ**
Anterior view.



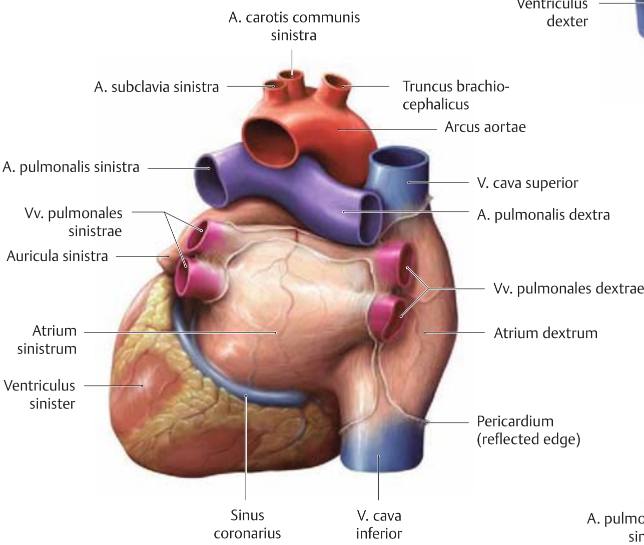
Heart: Surfaces & Chambers

Note the reflection of lamina visceralis (epicardium) to become lamina parietalis of the pericardium serosum.

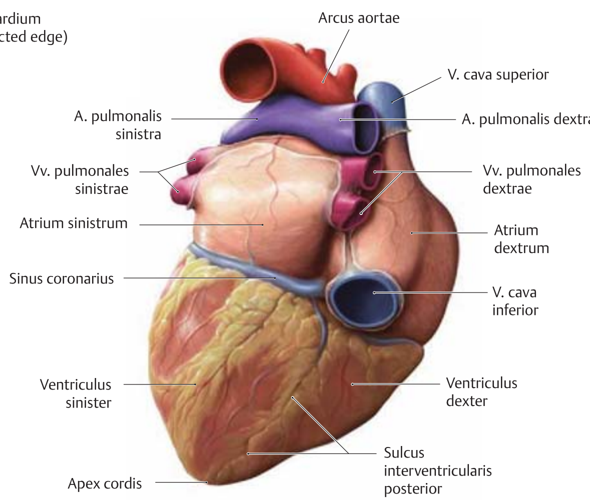
Fig. 7.11 **Surfaces of the heart**
The heart has three surfaces: anterior (facies sternocostalis), posterior (basis cordis), and inferior (facies diaphragmatica).



A Anterior surface (facies sternocostalis).

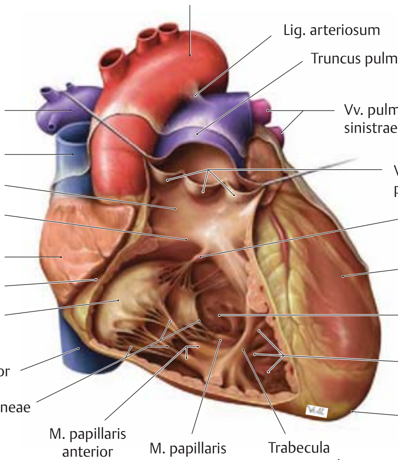


B Posterior surface (basis cordis).

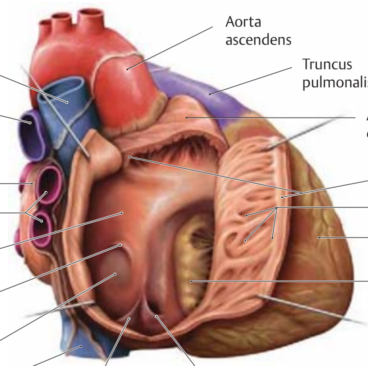


C Inferior surface (facies diaphragmatica).

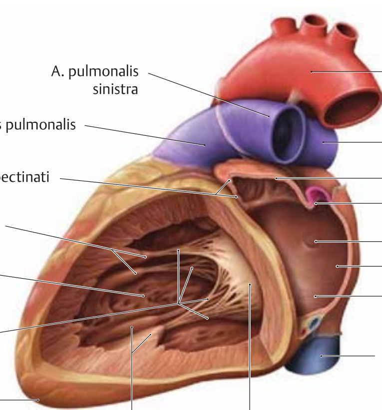
Fig. 7.12 **Chambers of the heart**



A Ventriculus dexter, anterior view. Note the crista supraventricularis, which marks the adult boundary between the embryonic ventricle and the bulbus cordis (now conus arteriosus).



B Atrium dextrum, right lateral view.

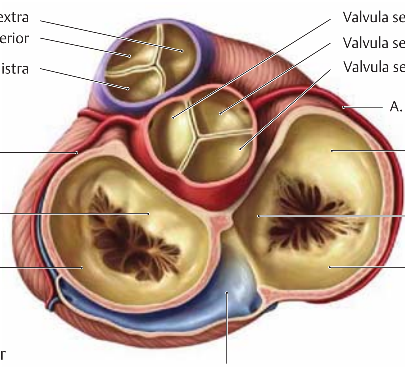


C Atrium sinister and ventriculus sinister, left lateral view. Note the irregular trabeculae carneae characteristic of the ventricular wall.

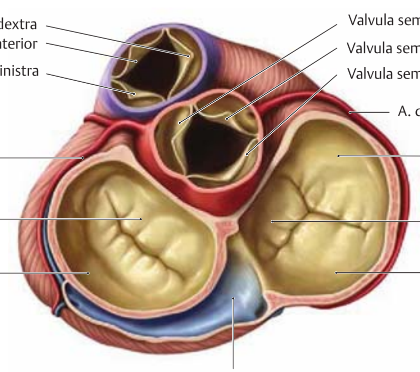
Heart: Valves

The cardiac valves are divided into two groups: semilunar and atrioventricular. The two semilunar valves (valva aortae and valva trunci pulmonalis) located at the base of the two great arteries of the heart regulate passage of blood from the ventricles to the aorta and truncus pulmonalis. The two valva atrioventricularis (sinistra and dextra) lie at the interface between the atria and ventricles.

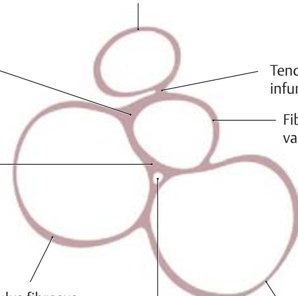
***Fig. 7.13* Cardiac valves**
Plane of cardiac valves, superior view. *Removed:* Atria and great arteries.



A Ventricular diastole (relaxation of the ventricles). *Closed:* Semilunar valves. *Open:* Atrioventricular valves.

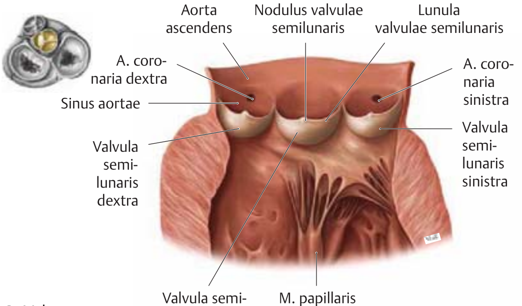


B Ventricular systole (contraction of the ventricles). *Closed:* Valvae atrioventriculares. *Open:* Valva aortae and valva trunci pulmonalis.

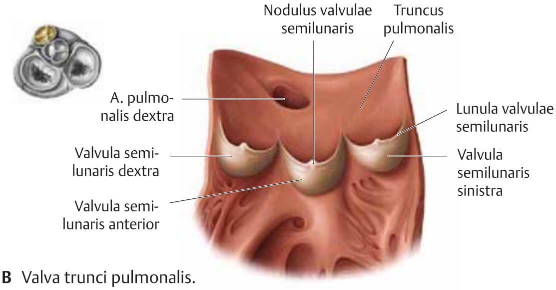


C Cardiac skeleton. The cardiac skeleton is formed by dense fibrous connective tissue. The anuli fibrosi (rings) and intervening trigonum fibrosum dextrum and sinister separate the atria from the ventricles. This provides mechanical stability, electrical insulation (see p. 90 for cardiac conduction system), and an attachment point for the cardiac muscles and valve cusps.

Fig. 7.14 Semilunar valves
Valves have been longitudinally sectioned and opened.

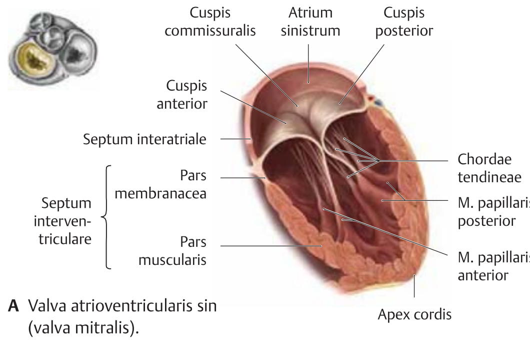


A Valva aortae.

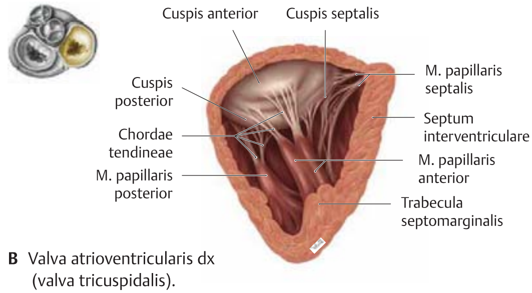


B Valva trunci pulmonalis.

Fig. 7.15 Atrioventricular valves
Anterior view during ventricular systole.



A Valva atrioventricularis sin (valva mitralis).



B Valva atrioventricularis dx (valva tricuspidalis).

Clinical

Auscultation of the cardiac valves
Heart sounds, produced by closure of the semilunar and atrioventricular valves, are carried by the blood flowing through the valve. The resulting sounds are therefore best heard "downstream," at defined auscultation sites (dark circles). Valvular heart disease causes turbulent blood flow through the valve; this produces a murmur that may be detected in the colored regions.

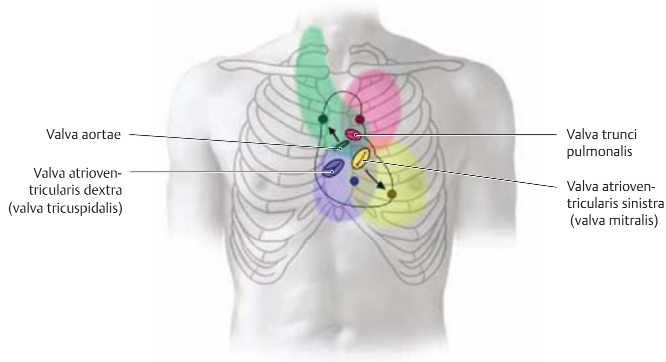
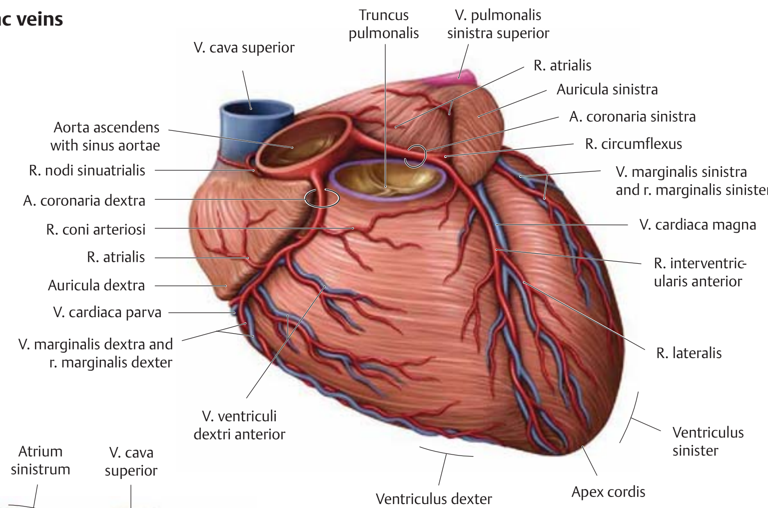


Table 7.2 Position and auscultation sites of cardiac valves

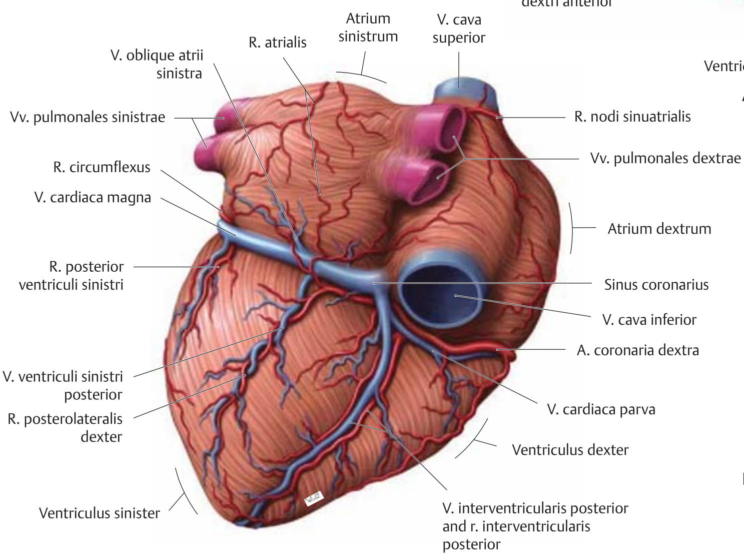
Valve	Anatomical projection	Auscultation site
Valva aortae	Left sternal border (at level of 3rd rib)	Right 2nd intercostal space (at sternal margin)
Valva trunci pulmonalis	Left sternal border (at level of 3rd costal cartilage)	Left 2nd intercostal space (at sternal margin)
Valva atrioventricularis sinistra (valva mitralis)	Left 4th/5th costal cartilage	Left 5th intercostal space (at midclavicular line) or apex cordis
Valva atrioventricular dextra (valva tricuspidalis)	Sternum (at level of 3rd costal cartilage)	Left 5th intercostal space (at sternal margin)

Arteries & Veins of the Heart

Fig. 7.16 **Coronary arteries and cardiac veins**



A Anterior view.



B Posteroinferior view. *Note*: Aa. coronariae dextrae and sinistrae typically anastomose posteriorly at the left atrium and ventricle.

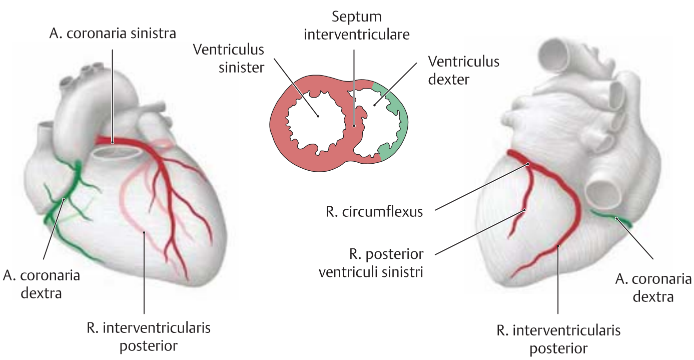
Table 7.3 **Branches of the coronary arteries**

A. coronaria sinistra	A. coronaria dextra
R. circumflexus • Rr. atriales • R. marginalis sinister • R. posterior ventriculi sinistra	R. nodi sinuatrialis
	R. coni arteriosi
	Rr. atriales
	R. marginalis dexter
R. interventricularis anterior (left anterior descending a., LAD) • R. coni arteriosi • R. lateralis • Rr. interventriculares septales	R. interventricularis posterior • Rr. interventriculares septales
	Rr. nodi atrioventricularis
	R. posterolateralis dexter

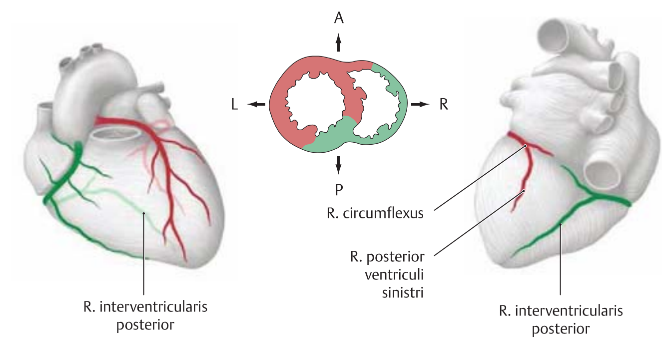
Table 7.4 **Divisions of the cardiac veins**

Vein	Tributaries	Drainage
Vv. cardiacae (cordis) anteriores (not shown)		Atrium dextrum
V. cardiaca (cordis) magna	V. interventricularis anterior	Sinus coronarius
	V. marginalis sinistra	
	V. obliqua atrii sinistra	
V. ventriculi sinistra posterior		
V. interventricularis posterior [v. cardiaca (cordis) media]		
Vv. cardiacae (cordis) minimae	Vv. ventricularis dextrae	
	V. marginalis dextra	

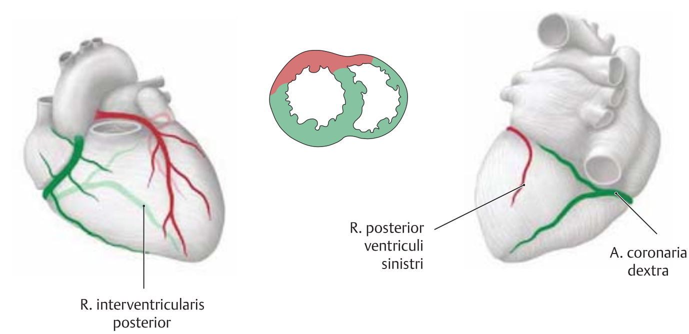
Fig. 7.17 **Distribution of the coronary arteries**
Anterior and posterior views of the heart, with superior views of transverse sections through the ventricles. The distribution of the coronary arteries differs from person to person. A. coronaria dextra and branches (green); a. coronaria sinistra and branches (red).



A Left coronary dominance (~15%).



B Balanced distribution (~70%).

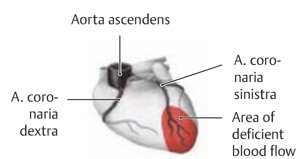


C Right coronary dominance (~15%).

Clinical

Disturbed coronary blood flow
Although the coronary arteries are connected by structural anastomoses, they are end arteries from a functional standpoint. The most frequent cause of deficient blood flow is *atherosclerosis*, a narrowing of the coronary lumen due to plaque-like deposits on the vessel wall. When the decrease in luminal size (stenosis) reaches a critical point, coronary blood flow is restricted, causing chest pain (*angina pectoris*). Initially, this pain is induced by physical effort, but eventually it persists at rest, often radiating to characteristic sites (e.g., left arm, left side of head and neck). A myocardial infarction occurs when deficient blood supply causes myocardial tissue to die (necrosis). The location and extent of the infarction depends on the stenosed vessel (see **A–E**, after Heinecker).

A Supra-apical anterior infarction.



B Apical anterior infarction.

C Anterior lateral infarction.

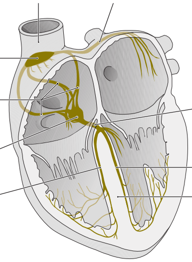
D Posterior lateral infarction.

E Posterior infarction.

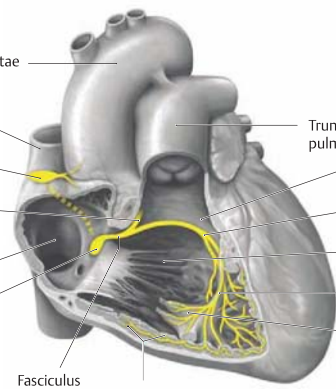
Conduction & Innervation of the Heart

Contraction of cardiac muscle is modulated by the cardiac conduction system. This system of specialized myocardial cells generates and conducts excitatory impulses in the heart. The conduction system contains two nodes, both located in the atria: the nodus sinuatrialis (SA node), known as the pacemaker, and the nodus atrioventricularis (AV node).

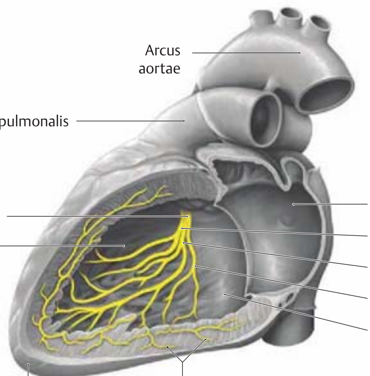
Fig. 7.18 Cardiac conduction system



A Anterior view. *Opened:* All four chambers.



B Right lateral view. *Opened:* Atrium dx and ventriculus dx.

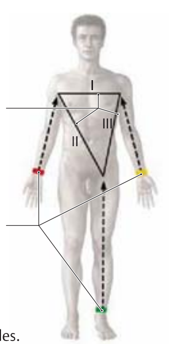


C Left lateral view. *Opened:* Atrium sinistrum and ventriculus sinister.

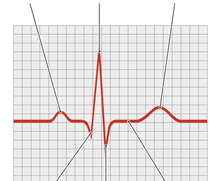
Clinical

Electrocardiogram (ECG)

The cardiac impulse (a physical dipole) travels across the heart and may be detected with electrodes. The use of three electrodes that separately record electrical activity of the heart along three axes or vectors (Einthoven limb leads) generates an electrocardiogram (ECG). The ECG graphs the cardiac cycle ("heartbeat"), reducing it to a series of waves, segments, and intervals. These ECG components can be used to determine whether cardiac impulses are normal or abnormal (e.g., myocardial infarction, chamber enlargement). *Note:* Although only three leads are required, a standard ECG examination includes at least two others (Goldberger, Wilson leads).



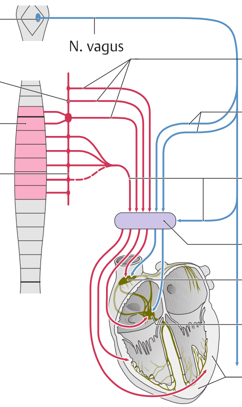
A ECG recording electrodes.



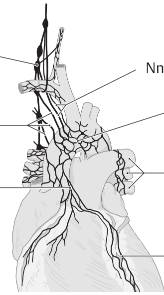
B ECG.

Sympathetic innervation: Presynaptic neurons from T1 to T6 spinal cord segments send fibers to synapse on postsynaptic neurons in the cervical and upper thoracic sympathetic ganglia. The three cervical nn. cardiaci and thoracic rr. cardiaci contribute to the cardiac plexus. Parasympathetic innervation: Presynaptic neurons and fibers reach the heart via rr. cardiaci, some of which also arise in the cervical region. They synapse on postsynaptic neurons near the SA node and along the coronary arteries.

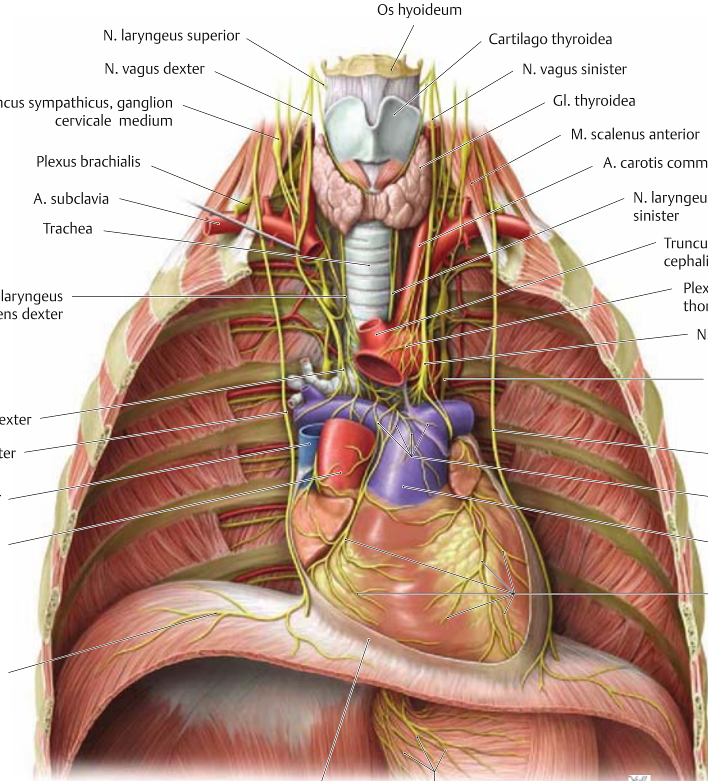
***Fig. 7.19* Autonomic innervation of the heart**



A Schematic.



B Autonomic plexuses of the heart, right lateral view. Note the continuity between the cardiac, aortic, and pulmonary plexuses.



C Autonomic nerves of the heart. Anterior view of opened thorax.

Heart: Radiology

Table 7.5 Borders of the heart

Border	Defining structures
Right cardiac border	Atrium dextrum
	V. cava superior
Apex cordis	Ventriculus sinister
Left cardiac border	Arcus aortae ("aortic knob")
	Truncus pulmonalis
	Atrium sinistrum
	Ventriculus sinister
Inferior cardiac border	Ventriculus sinister
	Ventriculus dexter

Fig. 7.20 Cardiac borders and configurations

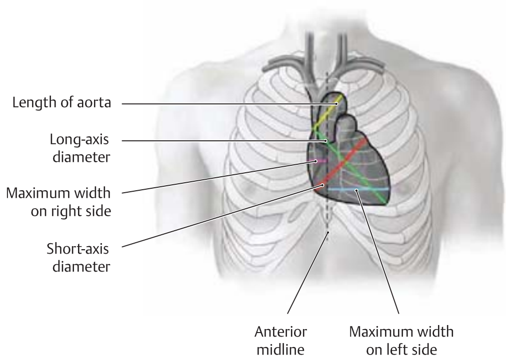
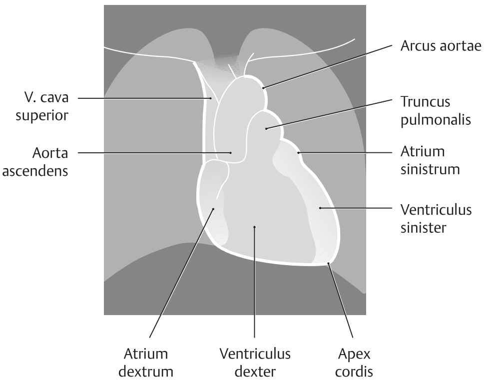
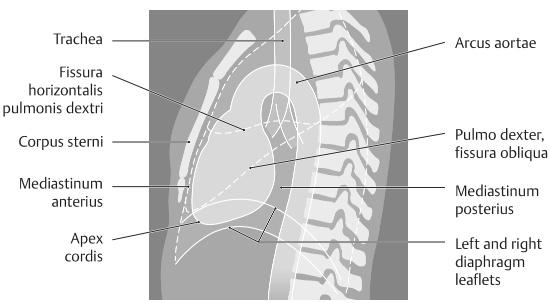


Fig. 7.21 Radiographic appearance of the heart



A Anterior view.

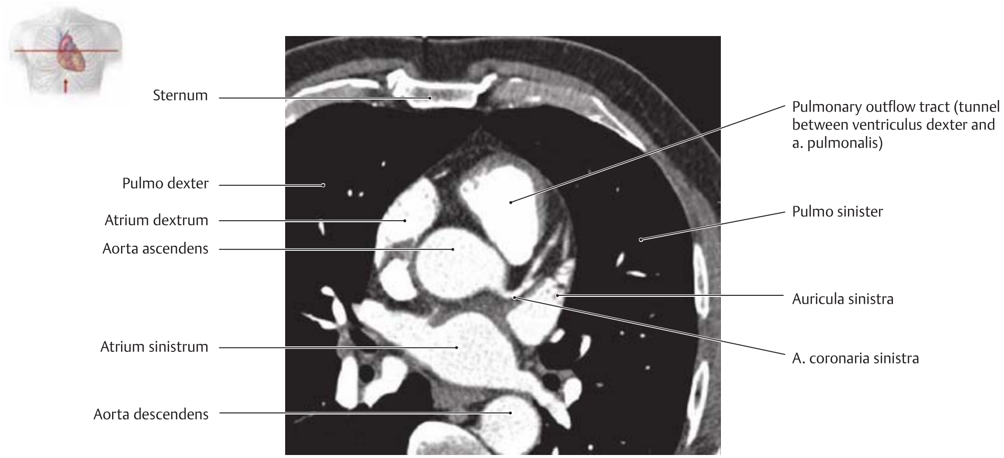
B Anteroposterior chest radiograph.



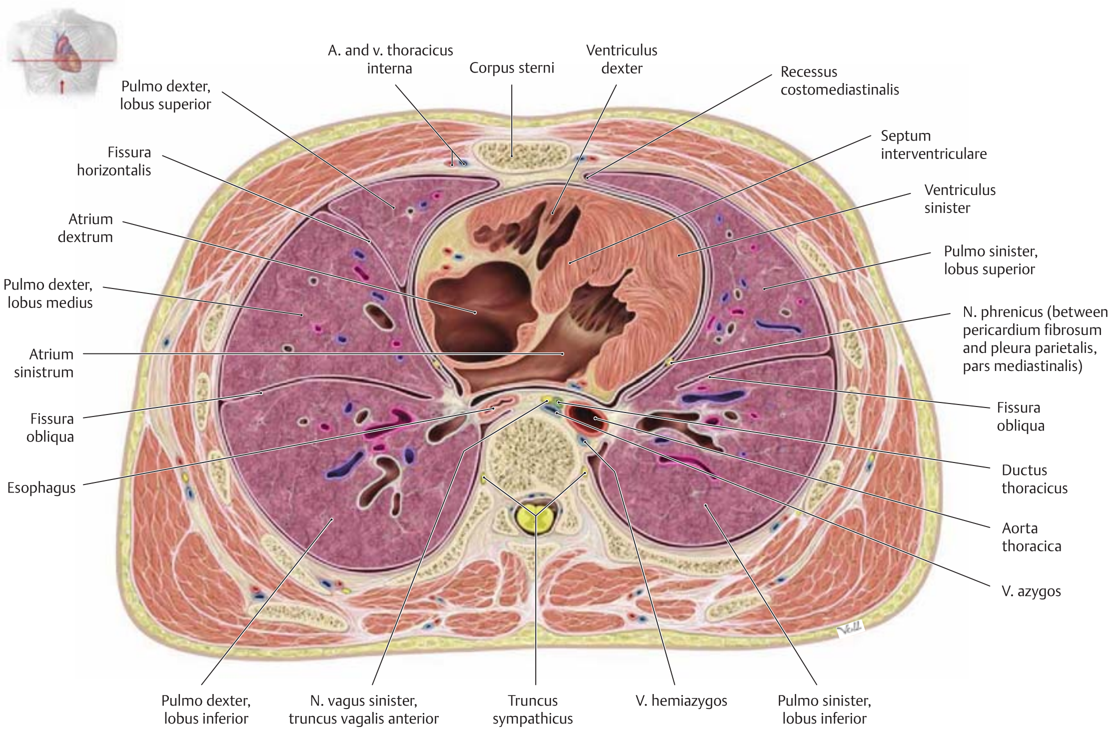
C Lateral view. *Visible:* Diaphragma leaflets and lungs. The arcus aortae forms a sling over the left bronchus principalis. Note the narrowness of the anterior mediastinum relative to the posterior mediastinum.

D Left lateral chest radiograph.

Fig. 7.22 **Heart in transverse section**



A Heart in normal chest magnetic resonance imaging (MRI). The cardiac chambers are clearly displayed owing to the high signal intensity, and the lungs are not visualized.



B Transverse section through T8, inferior view.

Pre- & Postnatal Circulation

Fig. 7.23 Prenatal circulation
After Fritsch and Kühnel.

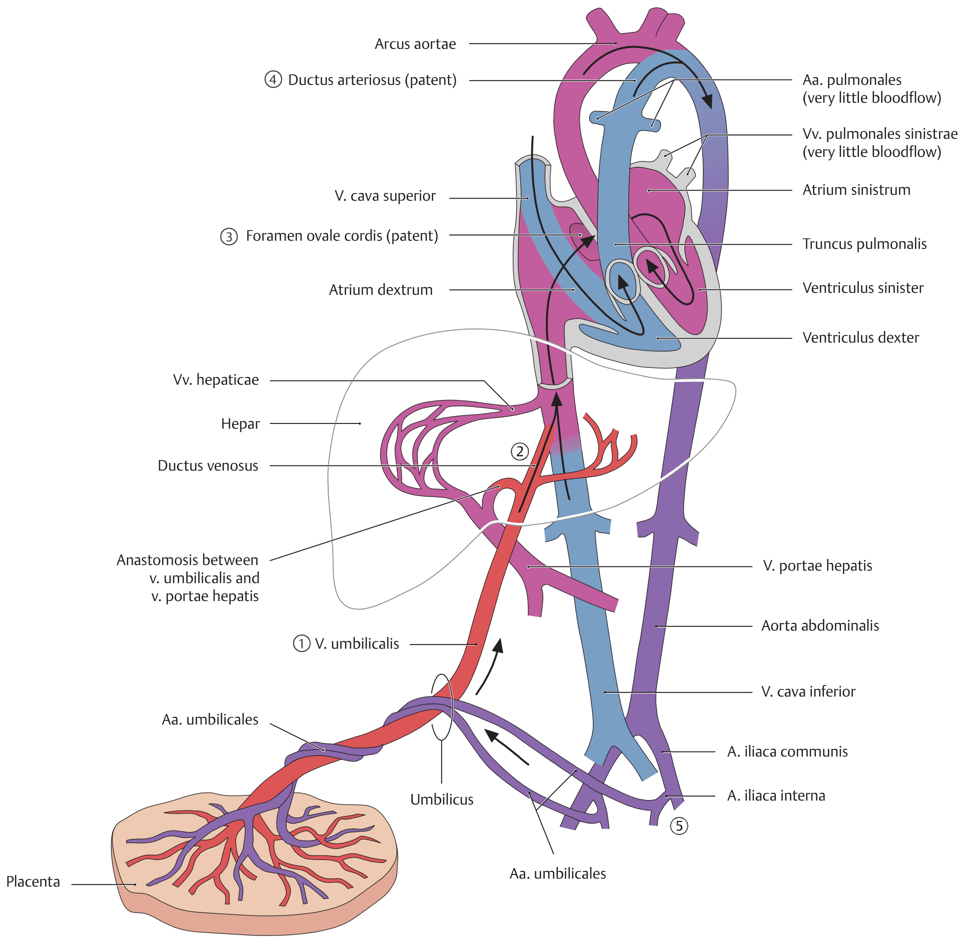
① Oxygenated and nutrient-rich fetal blood from the placenta passes to the fetus via the v. umbilicalis.

② Approximately half of this blood bypasses the liver (via ductus venosus) and enters v. cava inferior. The remainder enters v. portae to supply the liver with nutrients and oxygen.

③ Blood entering atrium dextrum from v. cava inferior bypasses ventriculus dx (as the lungs are not yet functioning) to enter atrium sinistrum via foramen ovale, a right-to-left shunt.

④ Blood from v. cava superior enters atrium dextrum, passes to ventriculus dexter, and moves into truncus pulmonalis. Most of this blood enters the aorta via the ductus arteriosus, a right-to-left shunt.

⑤ The partially oxygenated blood in the aorta returns to the placenta via the paired aa. umbilicales that arise from aa. iliacae interna.



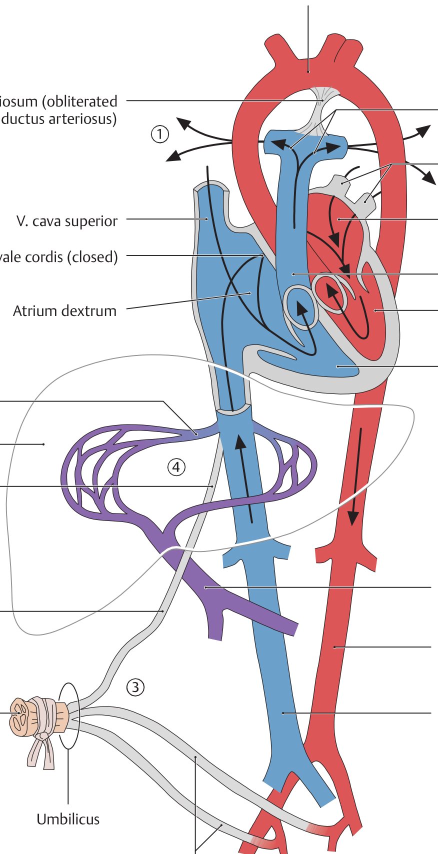
①As pulmonary respiration begins at birth, pulmonary blood pressure falls, causing blood from truncus pulmonalis to enter vv. pulmonales.

②The foramen ovale and ductus arteriosus close, eliminating the fetal right-to-left shunts. The pulmonary and systemic circulations in the heart are now separate.

③As the infant is separated from the placenta, aa. umbilicales occlude (except for the proximal portions), along with v. umbilicalis and ductus venosus.

④Blood to be metabolized now passes through the liver.

Fig. 7.24 **Postnatal circulation**
After Fritsch and Kühnel.



Clinical

Septal defects
Septal defects, the most common type of congenital heart defect, allow blood from the left chambers of the heart to improperly pass into the right chambers during systole. Ventrical septal defect (VSD, shown below) is the most common form. Patent foramen ovale, the most prevalent form of*atrial* septal defect (ASD), results from improper closure of the fetal shunt.

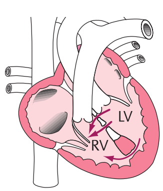


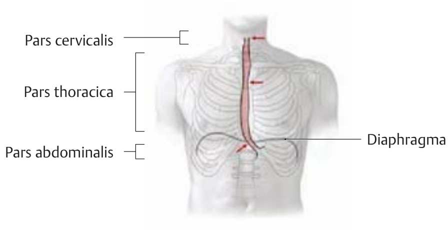
Table 7.6 **Derivatives of fetal circulatory structures**

Fetal structure	Adult remnant
Ductus arteriosus	Ligamentum arteriosum
Foramen ovale	Fossa ovalis
Ductus venosus	Ligamentum venosum
V. umbilicalis	Lig. teres hepatis
A. umbilicalis	Chorda a. umbilicalis

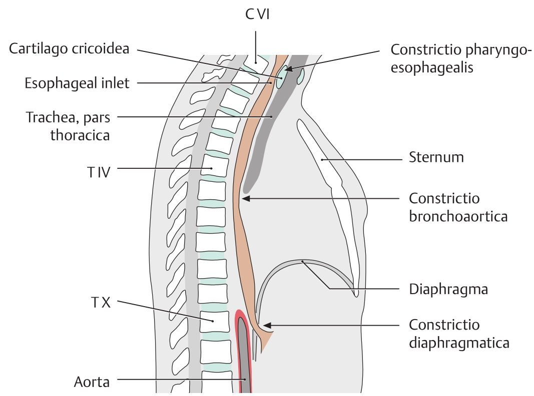
Esophagus

The esophagus is divided into three parts: cervical (C VI–T I), thoracic (T I to the esophageal hiatus of the diaphragm), and abdominal (the diaphragm to the cardiac orifice of the stomach). It descends slightly to the right of aorta thoracica and pierces diaphragma slightly to the left, just below processus xiphoideus.

Fig. 7.25 Esophagus: Location and constrictions



A Projection of esophagus onto chest wall. Esophageal constrictions are indicated with arrows.



B Esophageal constrictions, right lateral view.

Fig. 7.26 Esophagus in situ

Anterior view.

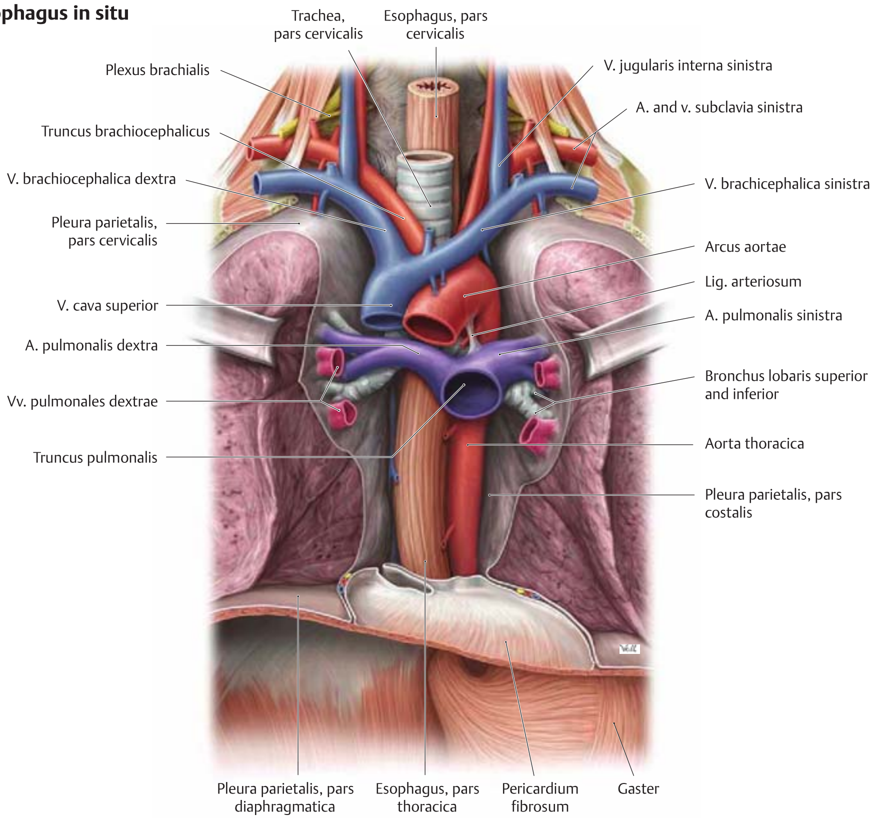
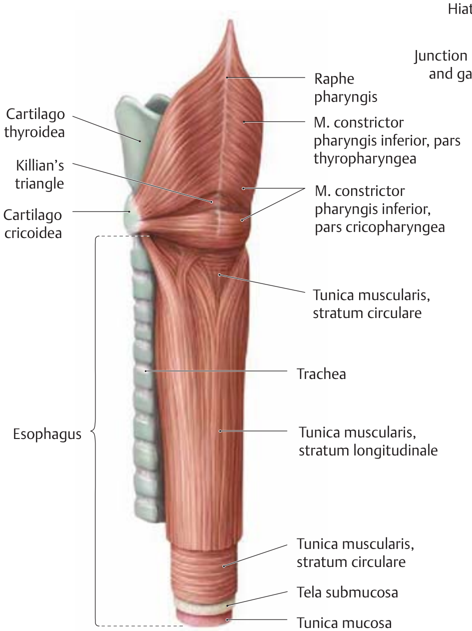
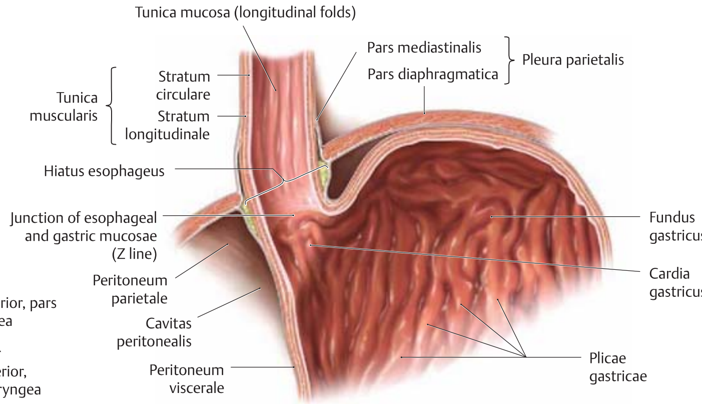


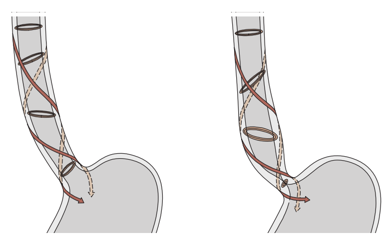
Fig. 7.27 Structure of the esophagus



A Esophageal wall, oblique left posterior view. Pharynx (p. 552); trachea (p. 110).

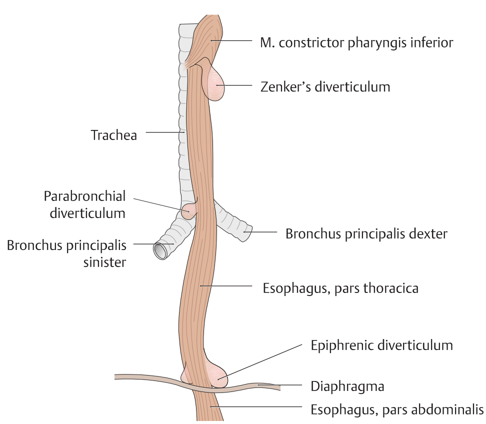


B Esophagogastric junction, anterior view. A true sphincter is not identifiable at this junction; instead, the diaphragmatic muscle of the hiatus esophageus functions as a sphincter. The junction of esophageal and gastric mucosae is often referred to as the "Z line" because of its zigzag form.



C Functional architecture of esophageal muscle.

Clinical



Esophageal diverticula

Diverticula (abnormal outpouchings or sacs) generally develop at weak spots in the esophageal wall. There are three main types of esophageal diverticula:

- Hypopharyngeal (pharyngo-esophageal) diverticula: Outpouchings occurring at the junction of the pharynx and the esophagus. These include Zenker's diverticula (70% of cases).
- "True" traction diverticula: Protrusion of all wall layers, not typically occurring at characteristic weak spots. However, they generally result from an inflammatory process (e.g., lymphangitis) and are thus common at sites where the esophagus closely approaches the bronchi and bronchial lymph nodes (thoracic or parabronchial diverticula).
- "False" pulsion diverticula: Herniations of the mucosa and submucosa through weak spots in the muscular coat due to a rise in esophageal pressure (e.g., during normal swallowing). These include parahiatal and epiphrenic diverticula occurring above the esophageal aperture of the diaphragm (10% of cases).

Neurovasculature of the Esophagus

Sympathetic innervation: Presynaptic fibers arise from the T2–T6 spinal cord segments. Postsynaptic fibers arise from the truncus sympaticus to join the plexus esophageus. Parasympathetic innervation: Presynaptic fibers arise from the dorsal vagal nucleus and travel in the nn. vagi to form the extensive plexus esophageus *Note:* The postsynaptic neurons are in the wall of the esophagus. Fibers to the cervical portion of the esophagus travel in the n. laryngeus recurrens.

Fig. 7.28 **Autonomic innervation of the esophagus**

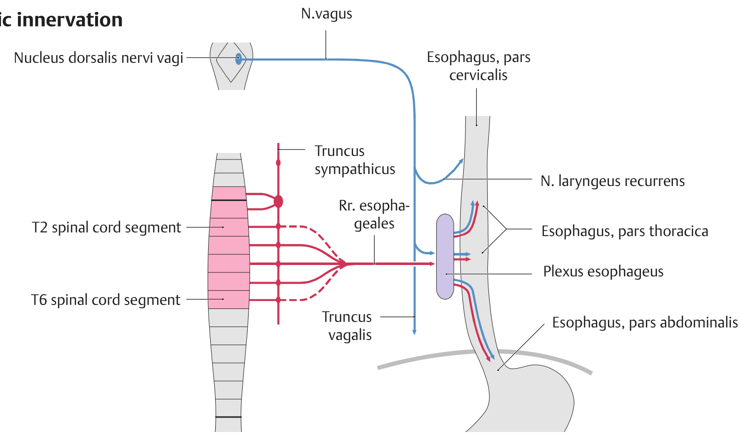
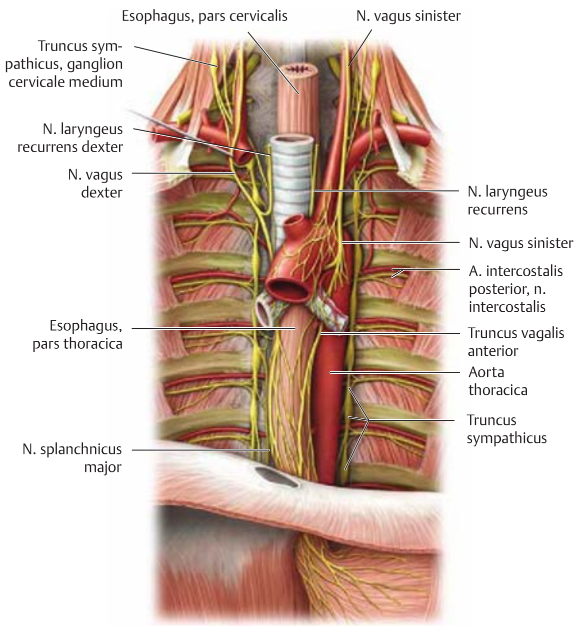
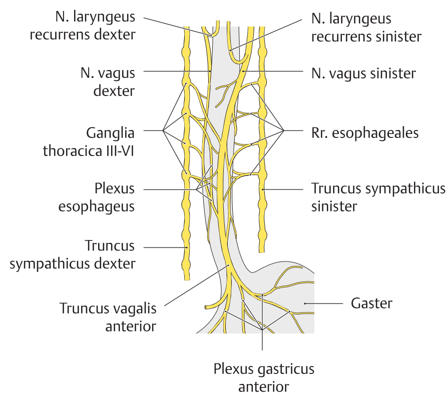


Fig. 7.29 **Esophageal plexus**

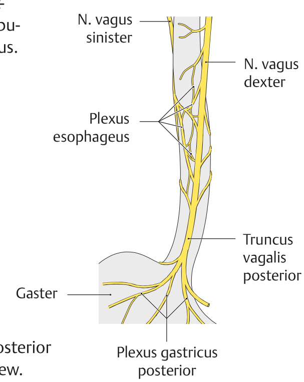
The left and right n. vagus initially descend on the left and right sides of the esophagus. As they begin to contribute to the plexus esophageus, they shift to anterior and posterior positions, respectively. As the nn. vagi continue into the abdomen, they are named the truncus vagalis anterior and posterior.



A Plexus esophageus in situ. Anterior view.



B Anterior view. Note the postsynaptic sympathetic contribution to the plexus esophageus.



C Posterior view.

Fig. 7.30 **Esophageal arteries**
Anterior view.

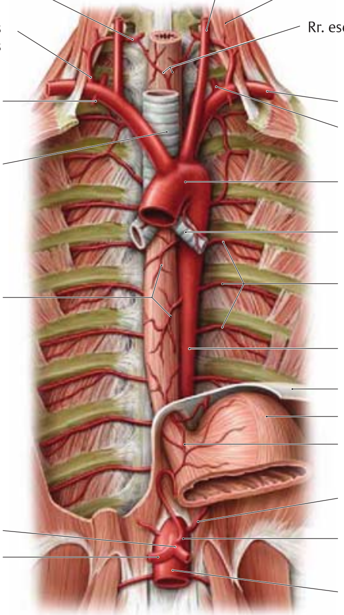


Fig. 7.31 **Esophageal veins**
Anterior view.

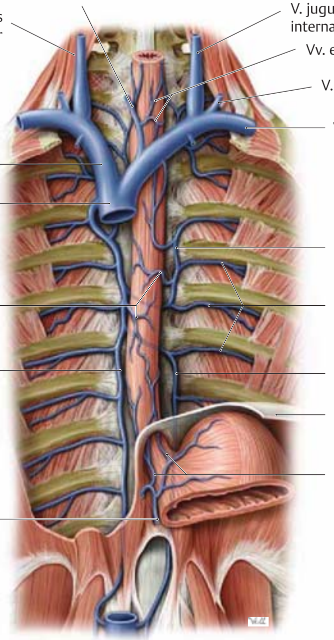


Table 7.7 Blood vessels of the esophagus

Part	Origin of esophageal arteries	Drainage of esophageal veins
Pars cervicalis	A. thyroida inferior	V. thyroida inferior
	Rarely direct branches from truncus thyro-cervicalis or a. carotis communis	V. brachiocephalica sinistra
Pars thoracica	Aorta (four or five aa. esophageales)	Upper left: V. hemiazygos accessoria or v. brachio-cephalica sinistra
		Lower left: V. hemiazygos
		Right side: V. azygos
Pars abdominalis	A. gastrica sinistra	V. gastrica sinistra

Lymphatics of the Mediastinum

The nll. phrenici superiores drain lymph from the diaphragm, pericardium, lower esophagus, lung, and liver into the truncus bronchomediastinalis. The nll. phrenici inferiores, found in the abdomen, collect lymph from the diaphragm and lower lobes of the lung and convey it to the truncus lumbalis. *Note:* The pericardium may also drain superiorly to the nll. brachiocephalici.

Fig. 7.32 **Lymph nodes of the mediastinum and thoracic cavity**
Left anterior oblique view.

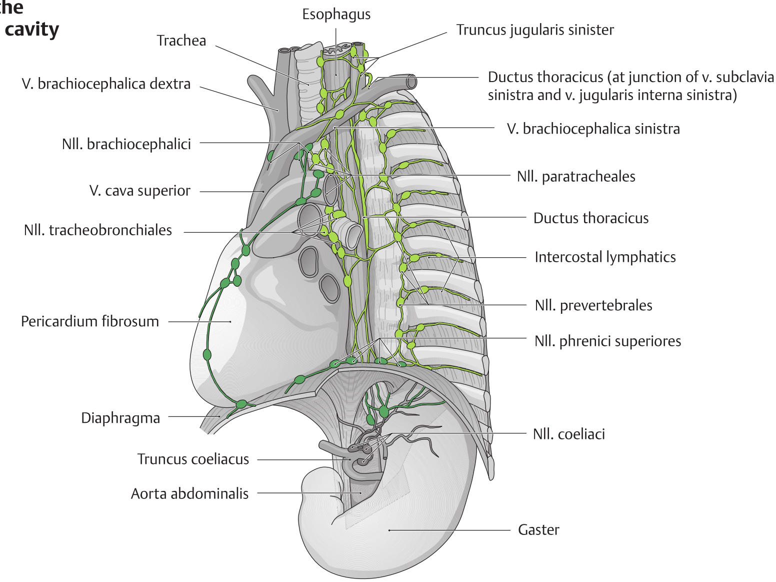
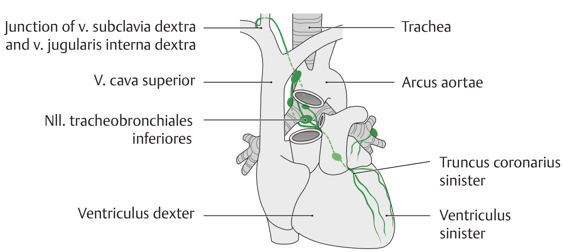
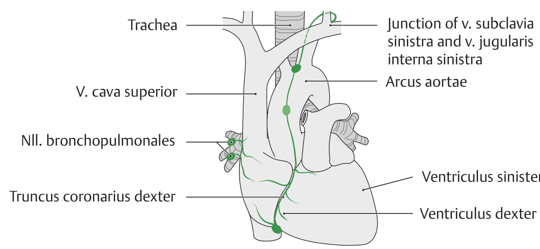


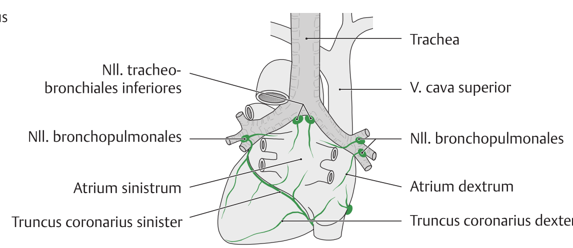
Fig. 7.33 **Lymphatic drainage of the heart**
A unique “crossed” drainage pattern exists in the heart: lymph from the left atrium and ventricle drains to the right venous junction, whereas lymph from the right atrium and ventricle drains to the left venous junction.



A Lymphatic drainage of the left chambers, anterior view.



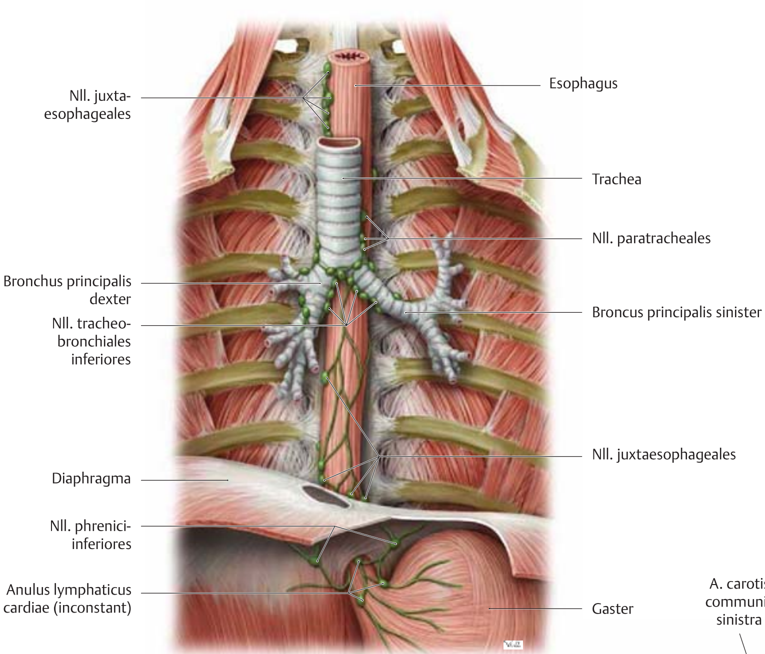
B Lymphatic drainage of the right chambers, anterior view.



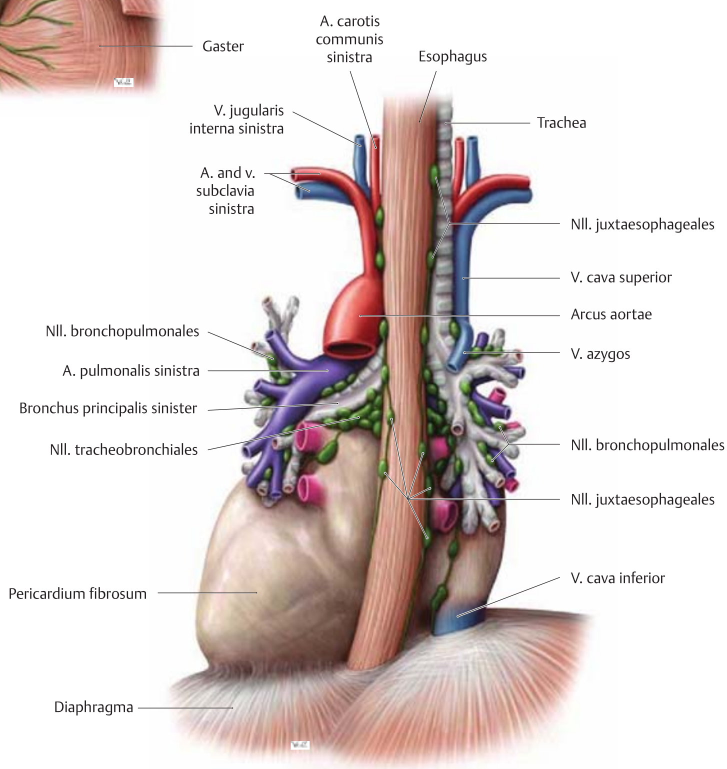
C Posterior view.

The nll. juxtaesophageales drain the esophagus. Lymphatic drainage of the cervical part of the esophagus is primarily cranial, to the nll. cervicales profundi and then to the truncus jugularis. The thoracic part of the esophagus drains to the trunci bronchomediastinales in two parts: the upper half drains cranially, and the lower half drains inferiorly via the nll. phrenici superiores. The nll. bronchopulmonales and paratracheales drain lymph from the lungs, bronchi, and trachea into the truncus bronchomediastinales (see p. 118).

Fig. 7.34 **Mediastinal lymph nodes**



A Anterior view of opened thorax.

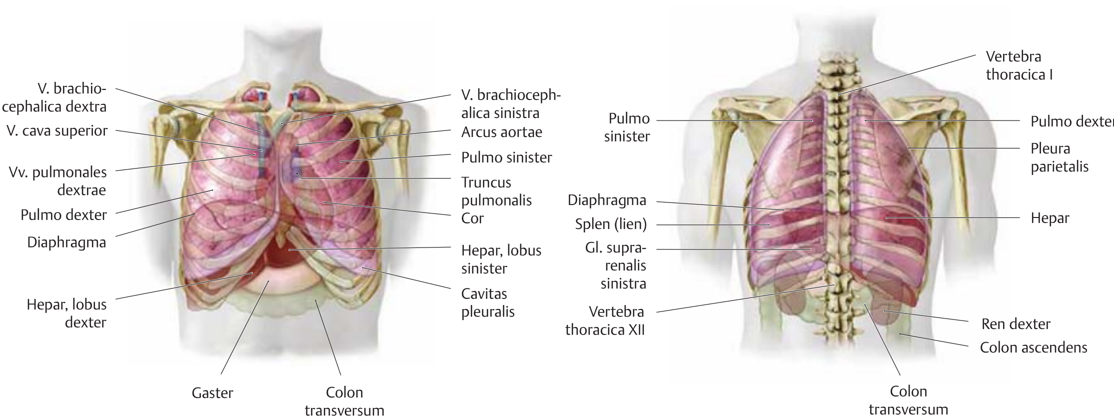


B Posterior view of mediastinal lymph nodes.

Pleural Cavity

The paired pleural cavities (cavitas pleuralis) contain the left and right lungs. They are completely separated from each other by the mediastinum and are under negative atmospheric pressure (see respiratory mechanics, pp. 112–113).

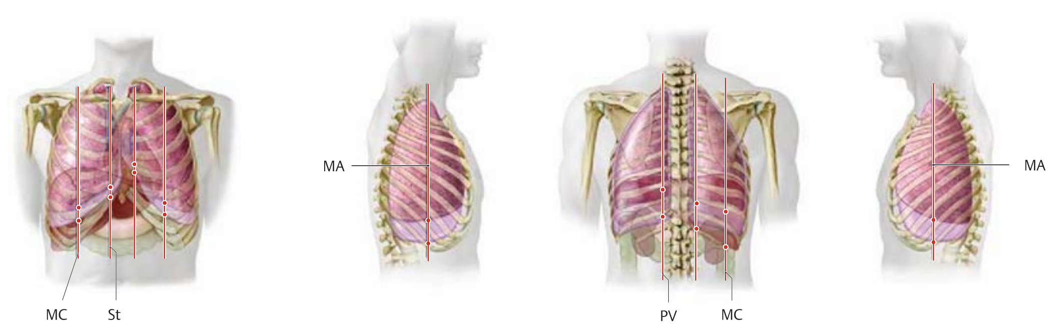
Fig. 8.1 **Pleural cavity**
Pleural cavities and lungs projected onto thoracic skeleton.



A Anterior view.

B Posterior view.

Fig. 8.2 **Boundaries of the pleural cavities and lungs**



A Anterior view.

B Right lateral view.

C Posterior view.

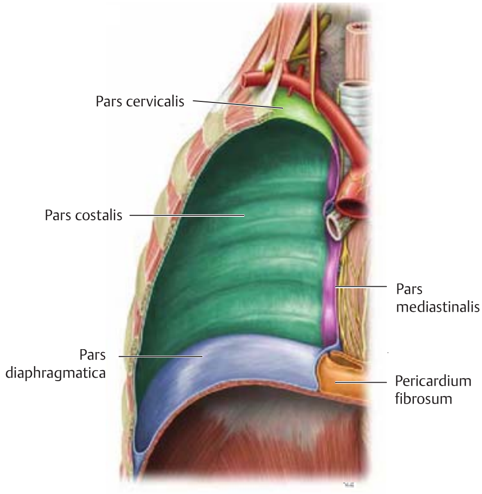
D Left lateral view.

Table 8.1 **Pleural cavity boundaries and reference points**

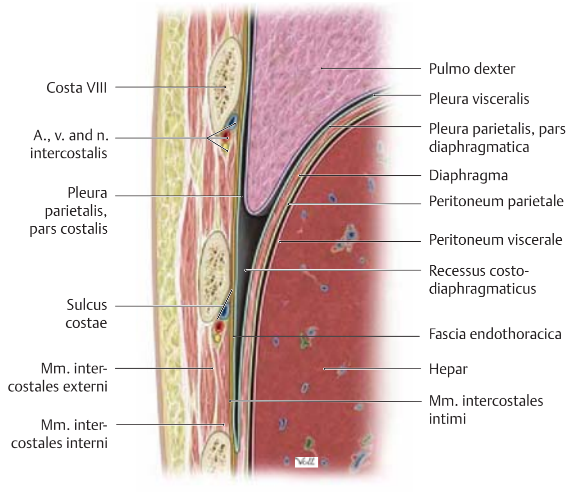
Reference line	Right pleura parietale	Pulmodexter	Pulmo sinister	Left pleura parietale
Sternal line (St)	Costa VII	Costa VI	Costa IV	Costa IV
Midclavicular line (MC)	Cartilago costalis costa VIII	Costa VI	Costa VI	Costa VIII
Midaxillary line (MA)	Costa X	Costa VIII	Costa VIII	Costa X
Paravertebral line (PV)	Vertebra Th XII	Costa X	Costa X	Vertebra Th XII

Fig. 8.3 **Pleura parietale**

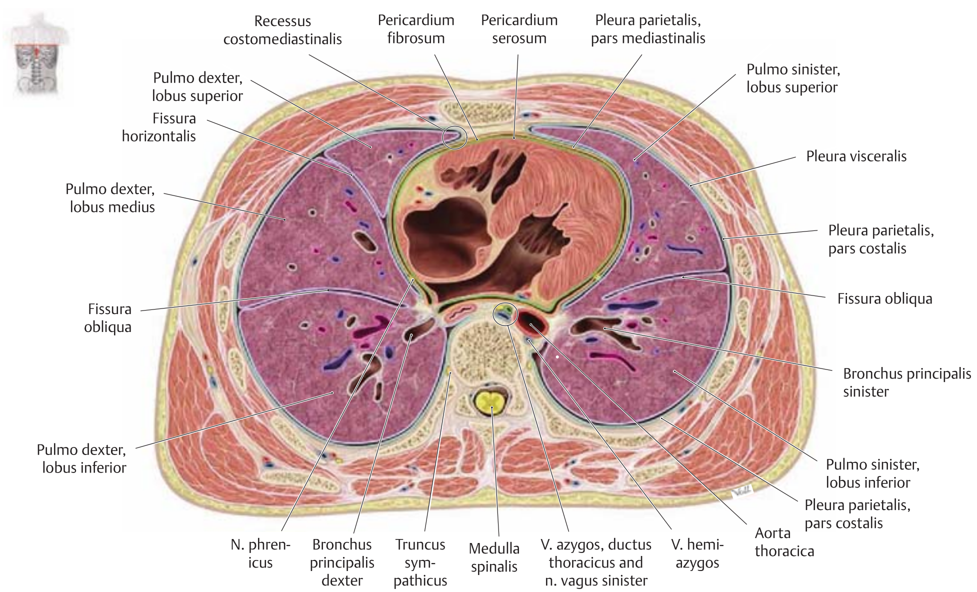
The pleural cavity is bounded by two serous layers. The pleura visceralis (pulmonalis) covers the lungs, and the pleura parietale lines the inner surface of the thoracic cavity. The four parts of the pleura parietale (pars costalis, pars diaphragmatica, pars mediastinalis, and cupula pleura) are continuous.



A Parts of the pleura parietale. *Opened:* Right pleural cavity, anterior view.



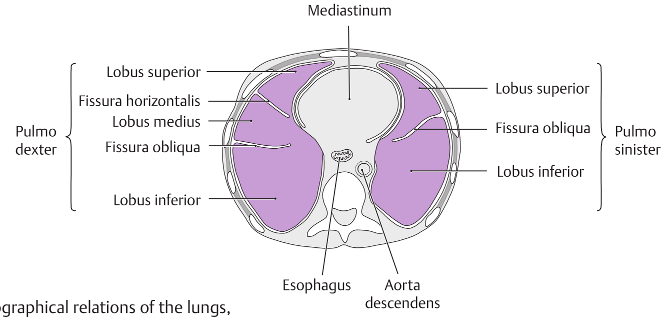
B Recessus costodiaphragmaticus, coronal section, anterior view. Reflection of the pars diaphragmatica onto the inner thoracic wall (becoming the pars costalis) forms the recessus costodiaphragmaticus.



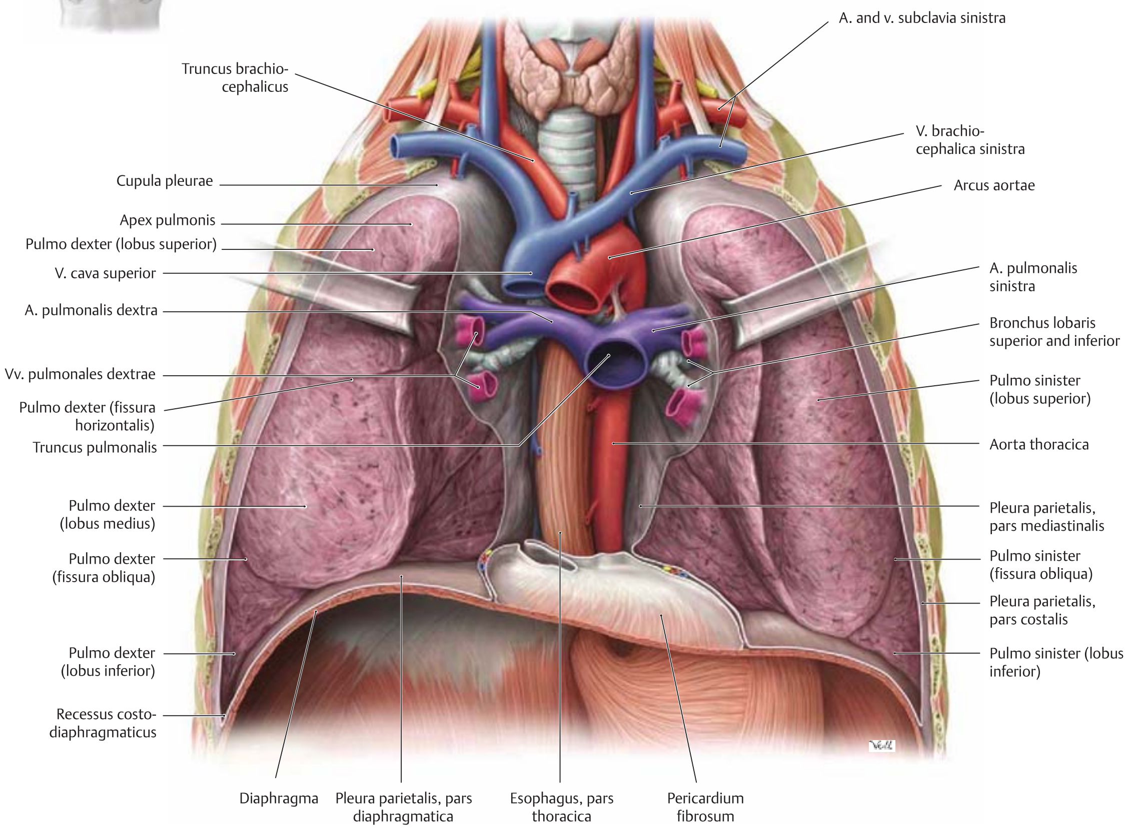
C Transverse section, inferior view. Reflection of the pars costalis pleura parietalis onto the pericardium forms the recessus costomediastinalis.

Lungs in Situ

Fig. 8.4 **Lungs in situ**
The left and right lungs occupy the full volume of the pleural cavity. Note that the left lung is slightly smaller than the right due to the asymmetrical position of the heart.



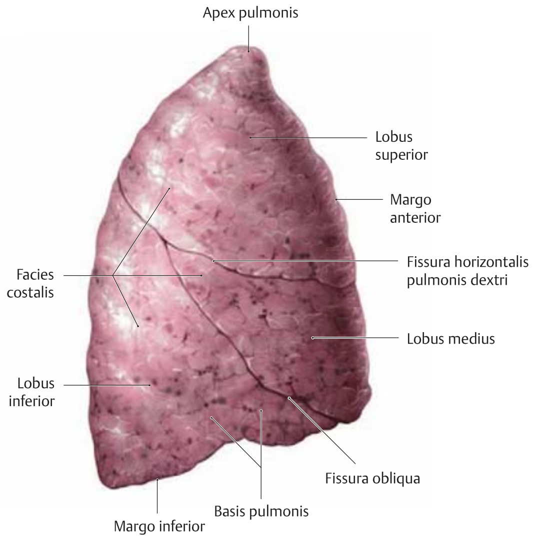
A Topographical relations of the lungs, transverse section, inferior view.



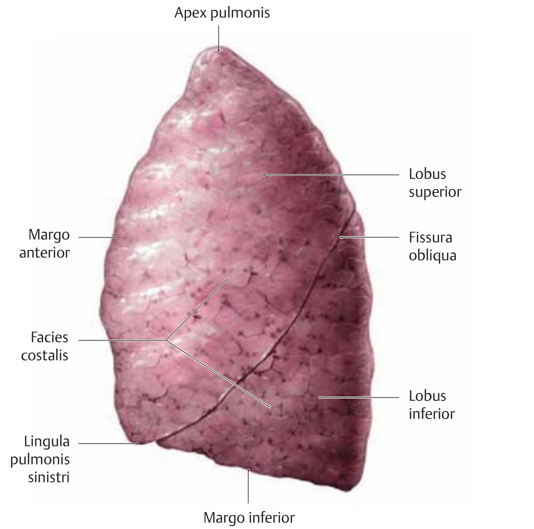
B Anterior view with lungs retracted.

The fissura obliqua and fissura horizontalis divide the right lung into three lobi: superior, middle, and inferior. The fissura obliqua divides the left lung into two lobi: superior and inferior. The apex of each lung extends into the root of the neck. The hilum pulmonalis is the location at which the bronchi and neurovascular structures connect to the lung.

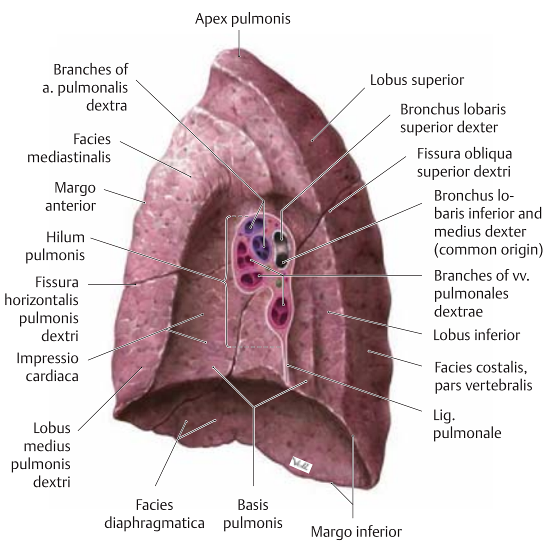
Fig. 8.5 **Gross anatomy of the lungs**



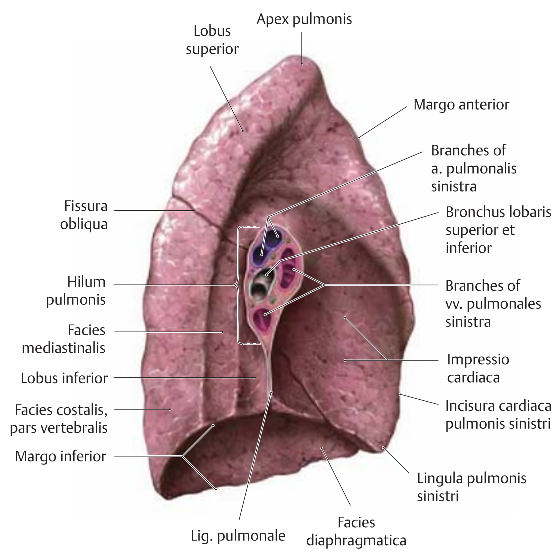
A Right lung, lateral view.



B Left lung, lateral view.



C Right lung, medial view.

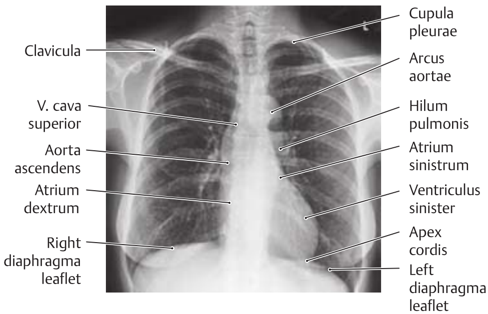


D Left lung, medial view.

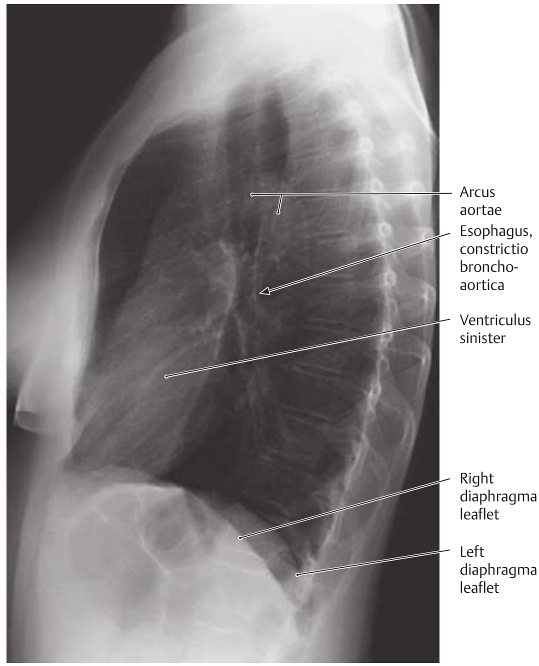
Lung: Radiology

The regions of the lungs show varying degrees of lucency in chest radiographs. The perihilar region where the main bronchi and vessels enter and exit the lung is less radiolucent than the peripheral region, which contains small-caliber vascular branches and segmental bronchi. The perihilarlung region is also covered by the heart. These "shadows" appear as white or bright areas on the radiograph (radiographs are negatives: areas that are impermeable to light will appear bright).

Fig. 8.6 Radiographic appearance of the lungs



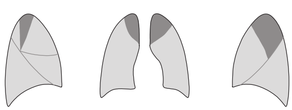
A Normal anteroposterior chest radiograph.



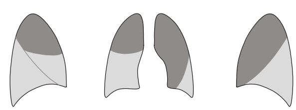
B Normal lateral chest radiograph.

Fig. 8.7 Opacity in lung diseases

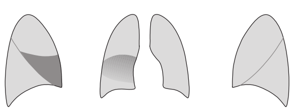
Lateral and anterior views of the right and left lungs. Opacity (decreased radiolucency) may be observed in diseased lung areas. Increased opacity may be due to fluid infiltration (inflammation) or tissue proliferation (neoplasia). These opacities are easier to detect in the peripheral part of the lung, which is inherently more radiolucent.*Note:* Opacities that conform to segmental lung boundaries are almost invariably due to pulmonary inflammation.



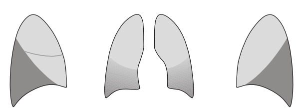
A Apical segment opacity.



B Upper lobe opacity.



C Middle lobe opacity. *Note*: The left lung has no middle lobe.

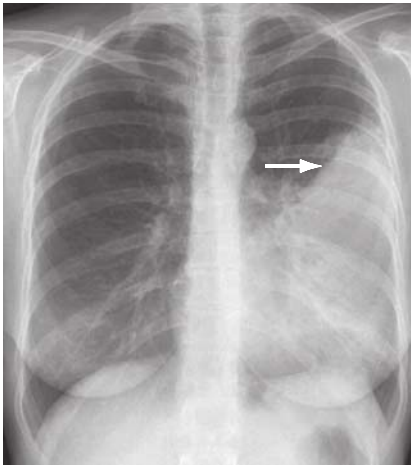


D Lower lobe opacity.

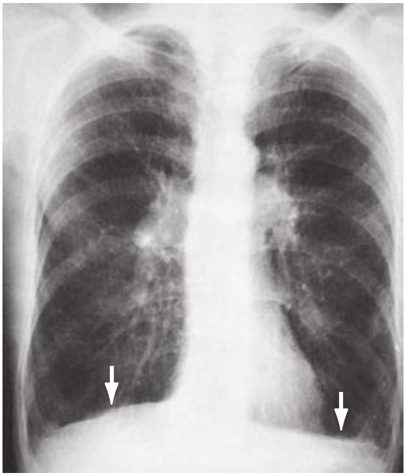
Clinical

Diseases of the lung

Increased opacity in the lungs does not necessarily correspond to segmental boundaries. Fluid accumulation in the lungs also creates characteristic “shadows” in pulmonary radiographs.



A Lingular pneumonia. The horizontal fissure can be seen (arrow). *Note*: The heart is much more difficult to visualize here due to increased opacity of segments IV and V.



B Pulmonary emphysema. The chest radiograph reveals diaphragmatic depression (flattening of the domes of the diaphragm, arrows) with corresponding changes in the orientation of the cardiac shadow. The heart assumes a vertical orientation due to the low diaphragm (a lateral radiograph would reveal an increased retrosternal space). The central pulmonary arteries are dilated but taper dramatically at the segmental level.

C Pulmonary edema complicating acute myocardial infarction. Dilation of vessels increases the number of visible vascular structures. This image shows a butterfly pattern of edema and bilateral pleural effusion.

D Tuberculosis. Note the thickening of the pleura and the radiating fibrous bands. This image does not contain the small pulmonary nodules (tuberculomas) often found in the upper zones of the lung.

Bronchopulmonary Segments of the Lungs

The lung lobes are subdivided into bronchopulmonary segments (segmenta bronchopulmonalia), each supplied by a tertiary (segmental) bronchus. *Note:* These subdivisions are not defined by surface boundaries but by origin.

Fig. 8.8 **Segmentation of the lung**
Anterior view. See pp. 110–111 for details of the trachea and bronchial tree.

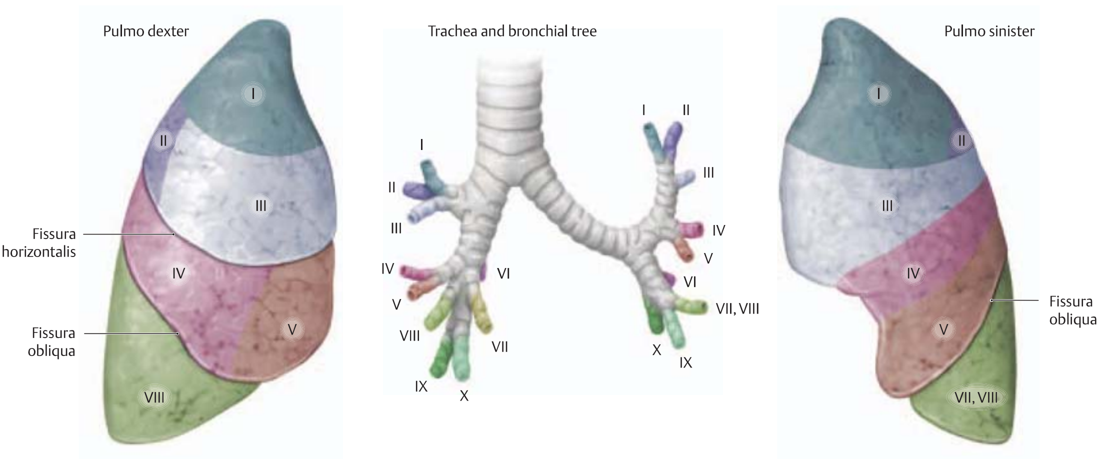


Fig. 8.9 **Posteroanterior bronchogram**
Anterior view of right lung.

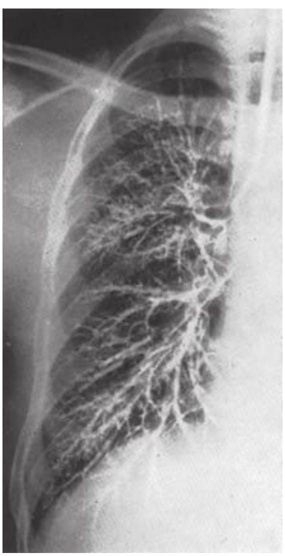
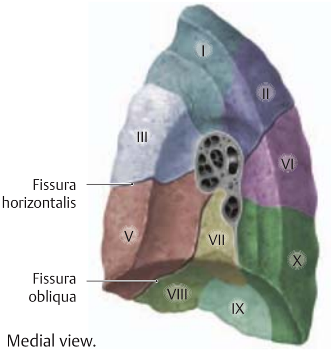


Table 8.2 **Segmental architecture of the lungs**

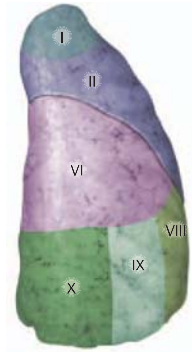
Each segment is supplied by a bronchus segmentalis of the same name (e.g., the bronchus segmentalis apicalis supplies the segmentum apicale). See pp. 110–111 for details of the trachea and bronchial tree.

Pulmo dexter		Pulmo sinister	
Lobus superior			
I	Segmentum apicale	Segmentum apicoposterius	I
II	Segmentum posterius		II
III	Segmentum anterius		III
Lobus medius		**Lingula pulmonis sinistra**	
IV	Segmentum laterale	Segmentum lingulare superius	IV
V	Segmentum mediale	Segmentum lingulare inferius	V
Inferior lobe			
VI	Segmentum superius		VI
VII	Segmentum basale mediale (cardiacum)		VII
VIII	Segmentum basale anterius		VIII
IX	Segmentum basale laterale		IX
X	Segmentum basale posterius		X

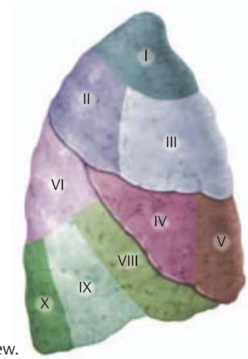
Fig. 8.10 **Right lung: Bronchopulmonary segments**



A Medial view.

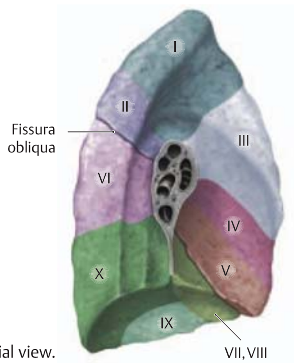


B Posterior view.

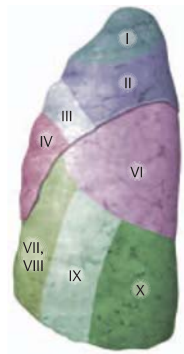


C Lateral view.

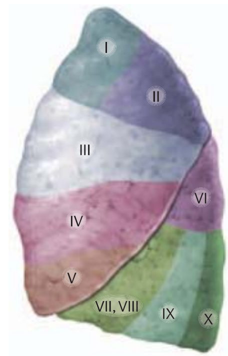
Fig. 8.11 **Left lung: Bronchopulmonary segments**



A Medial view.



B Posterior view.

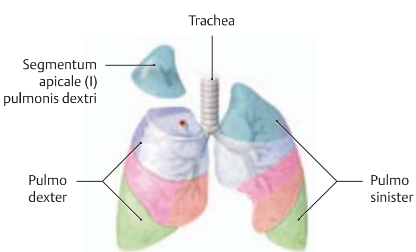


C Lateral view.

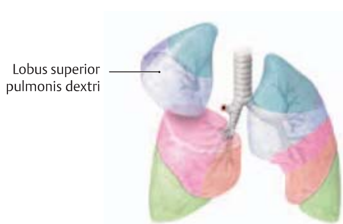
Clinical

Lung resections

Lung cancer, emphysema, or tuberculosis may necessitate the surgical removal of damaged portions of the lung. Surgeons exploit the anatomical subdivision of the lungs intolobes and segments when excising damaged tissue.



A Segmentectomy (wedge resection): Removal of one or more segments.



B Lobectomy: Removal of lobe.

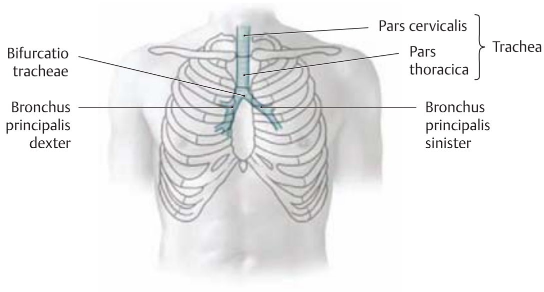
C Pneumonectomy: Removal of entire lung.

Trachea & Bronchial Tree

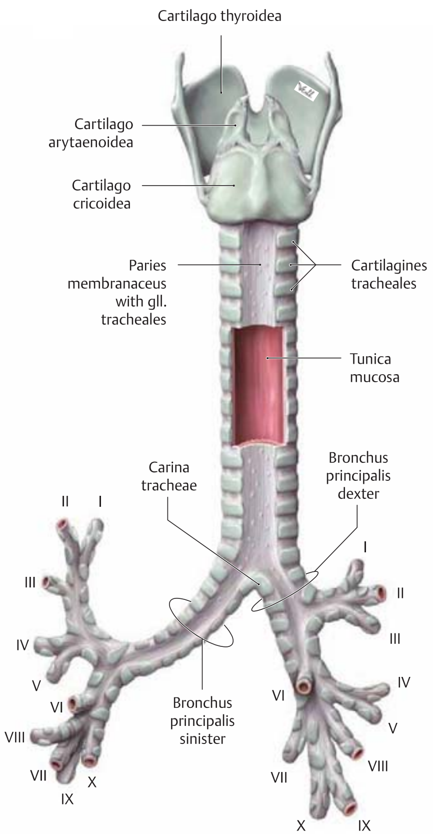
At or near the level of the angulus sterni, the lowest tracheal cartilage extends anteroposteriorly, forming the carina tracheae. The trachea bifurcates at the carina into the bronchi principales dexter and sinister. Each bronchus principalis gives off bronchi lobares to the corresponding lung.

Fig. 8.12 **Trachea**

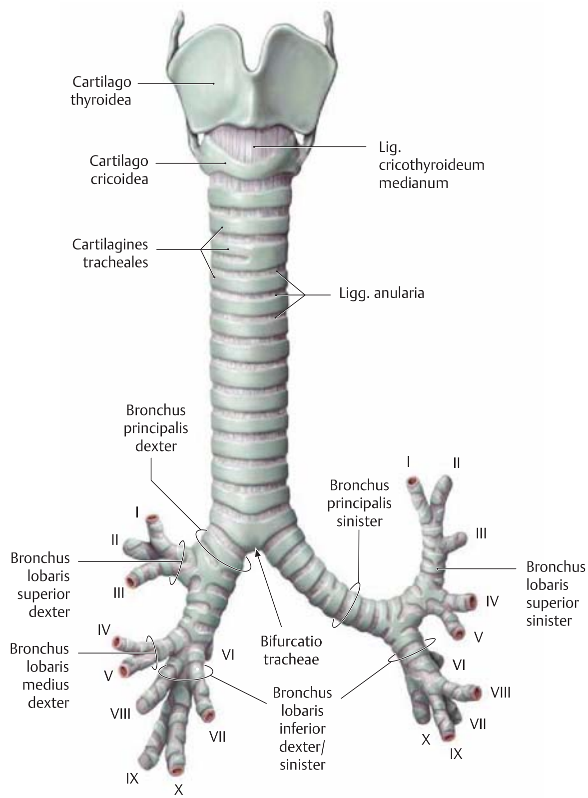
See p. 574 for the structures of the thyroid.



A Projection of trachea onto chest.



C Posterior view with opened posterior wall.



B Anterior view.

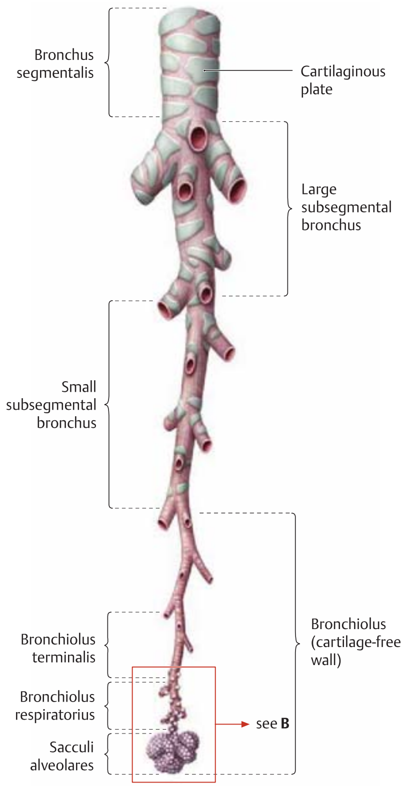
Clinical

Foreign body aspiration

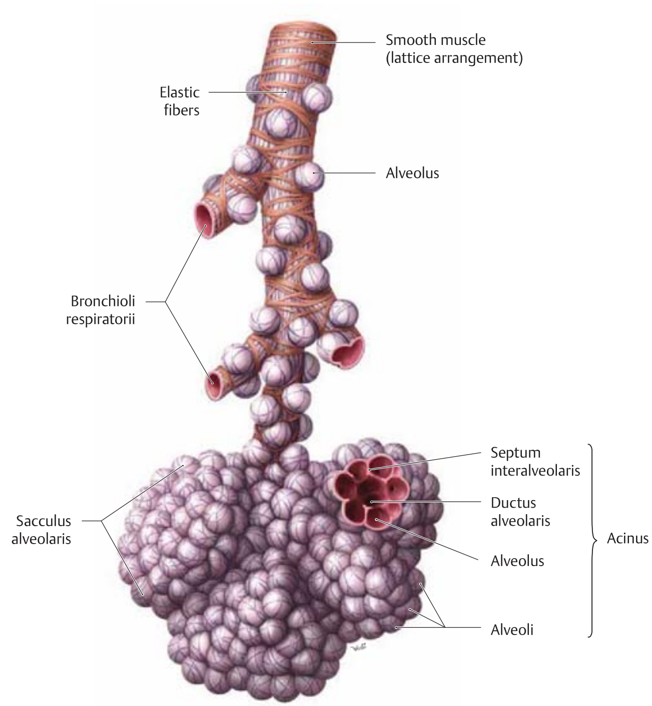
Toddlers are at particularly high risk of potentially fatal aspiration of foreign bodies. In general, foreign bodies are more likely to become lodged in the right bronchus principalis than the left: the left bronchus diverges more sharply at the tracheal bifurcation, while the right bronchus is relatively straight.

The conducting portion of the bronchial tree extends from the bifurcatio tracheae to the bronchiolus terminalis, inclusive. The respiratory portion consists of the bronchiolus respiratorius, ductuli alveolares, sacculi alveolares, and alveoli.

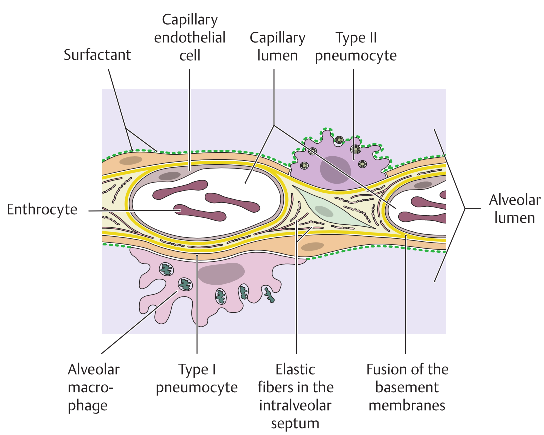
Fig. 8.13 **Bronchialtree**



A Divisions of the bronchial tree.



B Respiratory portion of the bronchial tree.



C Epithelial lining of the alveoli.

Clinical

Respiratory compromise

The most common cause of respiratory compromise at the bronchial level is asthma. Compromise at the alveolar level may result from increased diffusion distance, decreased aeration (emphysema), or fluid infiltration (e.g., pneumonia).

Diffusion distance: Gaseous exchange takes place between the alveolar and capillary lumens in the alveoli (see Fig. 8.13C). At these sites, the basement membranes of capillary endothelial cells are fused with those of type I alveolar epithelial cells, lowering the exchange distance to 0.5 µm. Diseases that increase this diffusion distance (e.g., edematous fluid collection or inflammation) result in compromised respiration.

Condition of alveoli: In diseases like emphysema, which occurs in chronic obstructive pulmonary disease (COPD), alveoli are destroyed or damaged. This reduces the surface area available for gaseous exchange.

Production of surfactant: Surfactant is a protein-phospholipid film that lowers the surface tension of the alveoli, making it easier for the lung to expand. The immature lungs of a preterm infant often fail to produce sufficient surfactant, leading to respiratory problems. Surfactant is produced and absorbed by alveolar epithelial cells (pneumocytes). Type I alveolar epithelial cells absorb surfactant; type II produce and distribute it.

Respiratory Mechanics

The mechanics of respiration are based on a rhythmic increase and decrease in thoracic volume, with an associated expansion and contraction of the lungs. *Inspiration* (red): Contraction of the diaphragm leaflets lowers the diaphragma into the inspiratory position, increasing the volume of the pleural cavity along the vertical axis. Contraction of the thoracic muscles (mm. intercostales externi, mm. scaleni, and m. serratus posterior) elevates the ribs, expanding the pleural cavity along the sagittal and transverse axes (Fig. 8.15A,B). Surface tension in the pleural space causes the pleura viscerale and parietale to adhere; thus, changes in thoracic volume alter the volume of the lungs. This is particularly evident in the pleural recesses: at functional residual capacity (resting position between inspiration and expiration), the lung does not fully occupy the pleural cavity. As the pleural cavity expands, a negative intrapleural pressure is generated. The air pressure differential results in an influx of air (inspiration). *Expiration* (blue): During passive expiration, the muscles of the thoracic cage relax and the diaphragma returns to its expiratory position. Contraction of the lungs increases the pulmonary pressure and expels air from the lungs. For forcible expiration, the mm. intercostalis interni (with the m. transversus thoracis and mm. subcostales) can actively lower the rib cage more rapidly and to a greater extent than through passive elastic recoil.

Fig. 8.14 **Respiratory changes in thoracic volume**
Inspiratory position (red); expiratory position (blue).

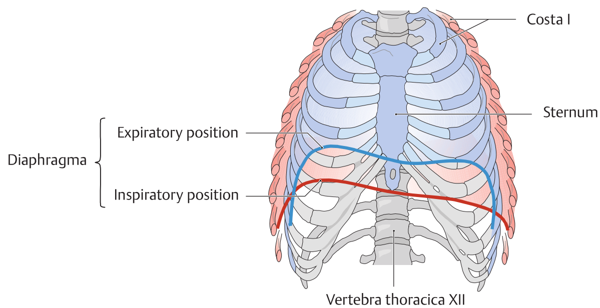
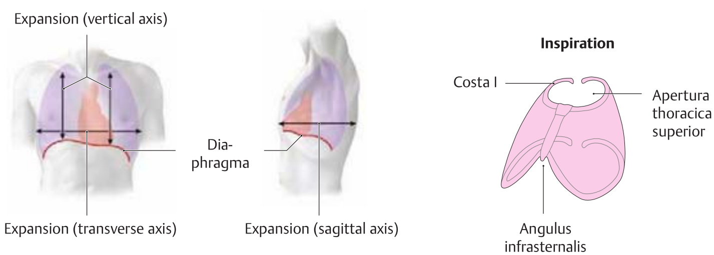
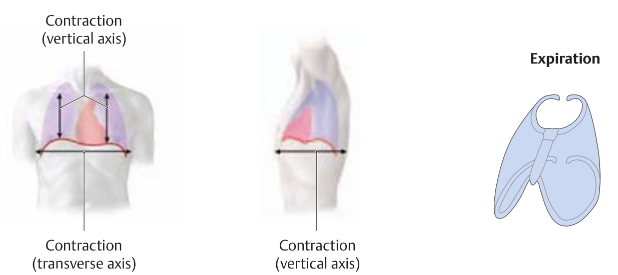


Fig. 8.15 **Inspiration: Pleural cavity expansion**



A Anterior view. **B** Left lateral view. **C** Anterolateral view.

Fig. 8.16 **Expiration: Pleural cavity contraction**



A Anterior view. **B** Left lateral view. **C** Anterolateral view.

Fig. 8.17 **Respiratory changes in lung volume**

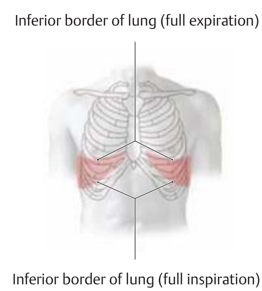


Fig. 8.18 **Inspiration: Lung expansion**

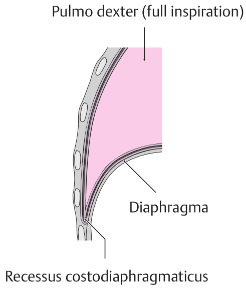


Fig. 8.19 **Expiration: Lung contraction**

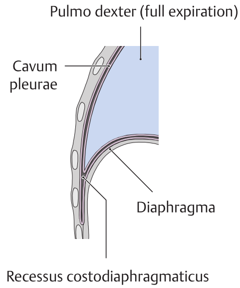
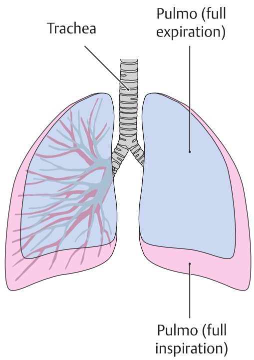
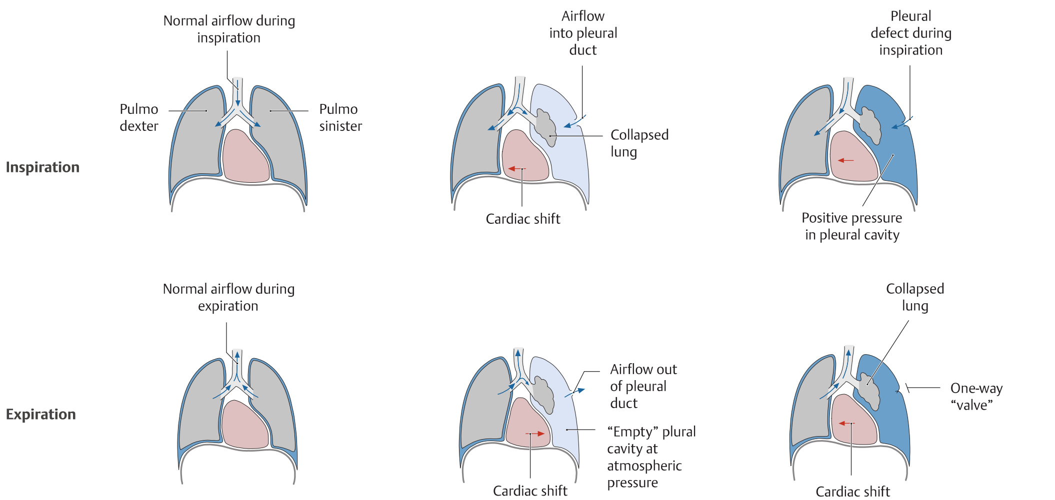


Fig. 8.20 **Movements of the lung and bronchial tree**
As the volume of the lung changes with the thoracic cavity, the entire bronchial tree moves within the lung. These structural movements are more pronounced in portions of the bronchial tree distant from the pulmonary hilum.



Clinical

Pneumothorax
The pleural space is normally sealed from the outside environment. Injury to the parietal pleura, visceral pleura, or lung allows air to enter the pleural cavity (pneumothorax). The lung collapses due to its inherent elasticity, and the patient's ability to breathe is compromised. The uninjured lung continues to function under normal pressure variations, resulting in "mediastinal flutter": the mediastinum shifts toward the normal side during inspiration and returns to the midline during expiration. Tension (valve) pneumothorax occurs when traumatically detached and displaced tissure covers the defect in the thoracic wall from the inside. This mobile flap allows air to enter, but not escape, the pleural cavity, causing a pressure buildup. The mediastinum shifts to the normal side, which may cause kinking of the great vessels and prevent the return of venous blood to the heart. Without treatment, tension pneumothorax is invariably fatal.

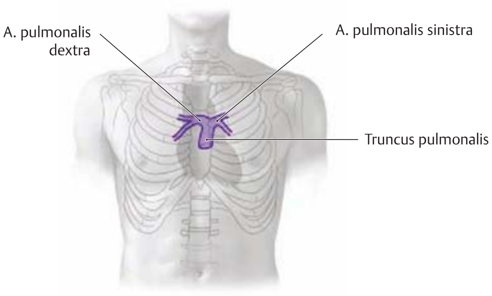


A Normal respiration. **B** Pneumothorax. **C** Tension pneumothorax.

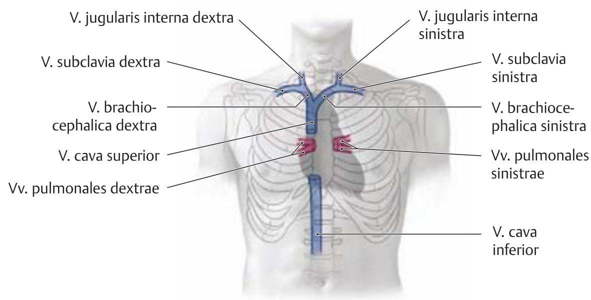
Pulmonary Arteries & Veins

The truncus pulmonalis arises from the right ventriculus and divides into a left and right a. pulmonalis for each lung. The paired vv. pulmonales open into the left atrium on each side. The aa. pulmonales accompany and follow the branching of the bronchial tree, whereas the vv. pulmonales do not, being located at the margins of the pulmonary lobules.

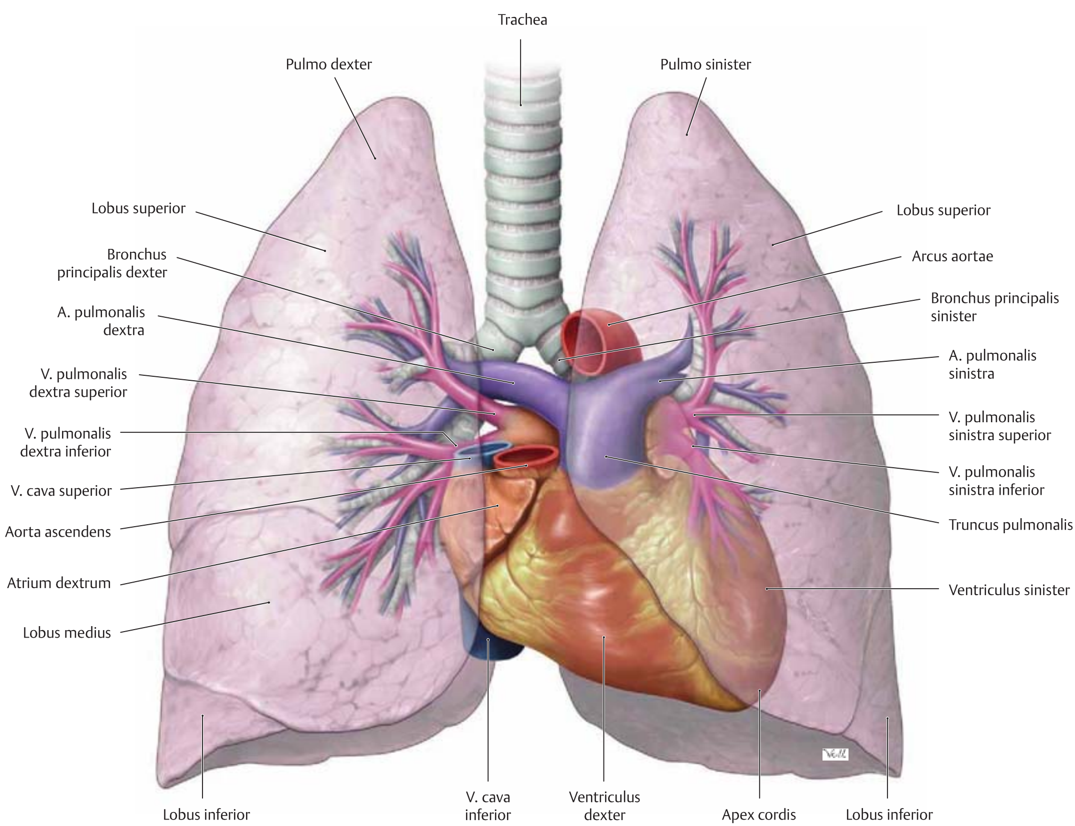
Fig. 8.21 **Pulmonary arteries and veins**
Anterior view.



A Projection of aa. pulmonales on chest wall.

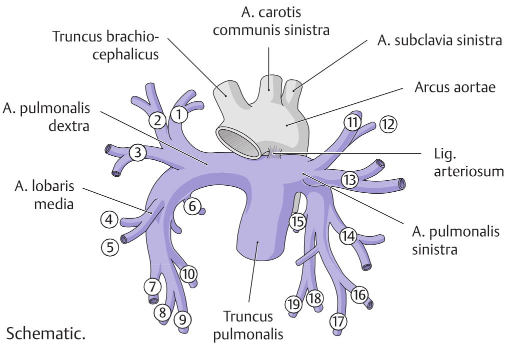


B Projection of vv. pulmonales on chest wall.



C Distribution of aa. and vv. pulmonales, anterior view.

Fig. 8.22 Aa. pulmonales

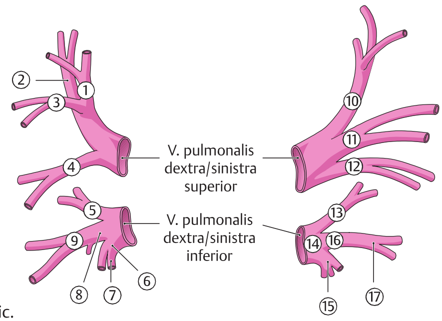


A Schematic.

Table 8.3	**Aa. pulmonales and their branches**		
A. pulmonales dextra			**A. pulmonales sinistra**
	Aa. lobares superiores		
①	A. segmentalis apicalis		⑪
②	A. segmentalis posterior		⑫
③	A. segmentalis anterior		⑬
	A. lobaris media		
④	A. segmentalis lateralis	A. lingularis	⑭
⑤	A. segmentalis medialis		
	Aa. lobares inferiores		
⑥	A. segmentalis superior		⑮
⑦	A. segmentalis basalis anterior		⑯
⑧	A. segmentalis basalis lateralis		⑰
⑨	A. segmentalis basalis posterior		⑱
⑩	A. segmentalis basalis medialis		⑲

B Pulmonary arteriogram, arterial phase, anterior view.

Fig. 8.23 Vv. pulmonales



A Schematic.

Table 8.4	**Vv. pulmonales and their tributaries**		
Vv. pulmonales dextra		**Vv. pulmonales sinistra**	
	Vv. superiores		
①	V. apicalis	V. apicoposterior	⑩
②	V. posterior		
③	V. anterior	V. anterior	⑪
④	V. lobi medii	V. lingularis	⑫
	Vv. inferiores		
⑤	V. superior		⑬
⑥	V. basalis communis		⑭
⑦	V. basalis inferior		⑮
⑧	V. basalis superior		⑯
⑨	V. basalis anterior		⑰

B Pulmonary arteriogram, venous phase, anterior view.

Clinical

Pulmonary embolism

Potentially life-threatening pulmonary embolism occurs when blood clots migrate through the venous system and become lodged in one of the arteries supplying the lungs. Symptoms include dyspnea (difficulty breathing) and tachycardia (increased heart rate). Most pulmonary emboli originate from stagnant blood in the veins of the lower limb and pelvis (venous thromboemboli). Causes include immobilization, disordered blood coagulation, and trauma. *Note:* A thromboembolus is a thrombus (blood clot) that has migrated (embolised).

Neurovasculature of the Tracheobronchial Tree

Fig. 8.24 **Pulmonary vasculature**
The pulmonary system is responsible for gaseous exchange within the lung. The branches of a. pulmonalis (shown in blue) carry *deoxygenated* blood and follow the bronchial tree. The branches of vv. pulmonales (red) are the only veins in the body carrying *oxygenated* blood, which they receive from the alveolar capillaries at the periphery of the lobulus.

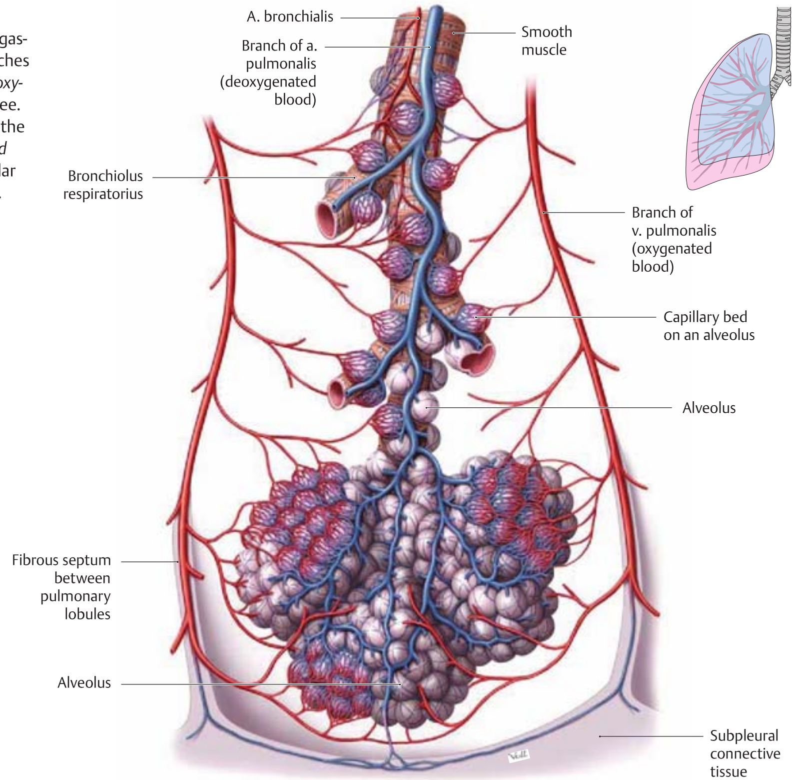


Fig. 8.25 **Aa. bronchiales**
The bronchial tree receives its nutrients via the aa. bronchiales, found in the adventitia of the airways. Typically, there are one to three aa. bronchiales arising directly from the aorta. Origin from an a. intercostalis posterior may also occur.

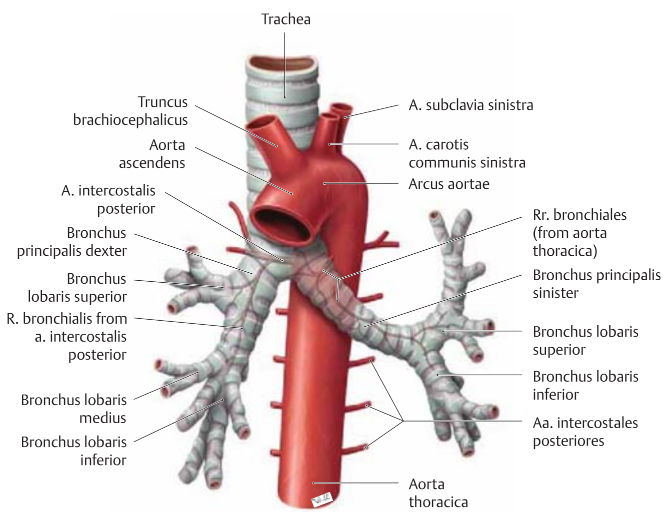


Fig. 8.26 **Vv. bronchiales**
Blood supplied by the aa. bronchiales is drained from the proximal tracheobronchial tree by the vv. bronchiales to the azygos system.

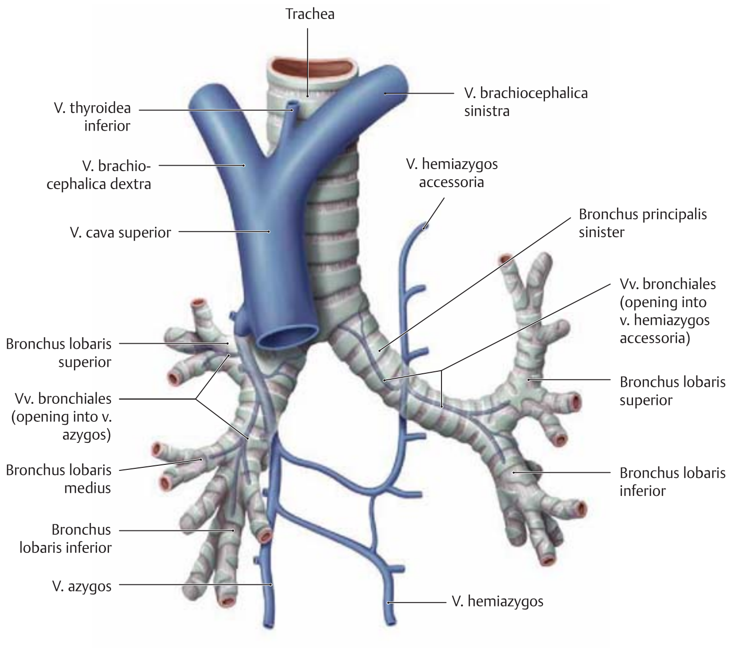
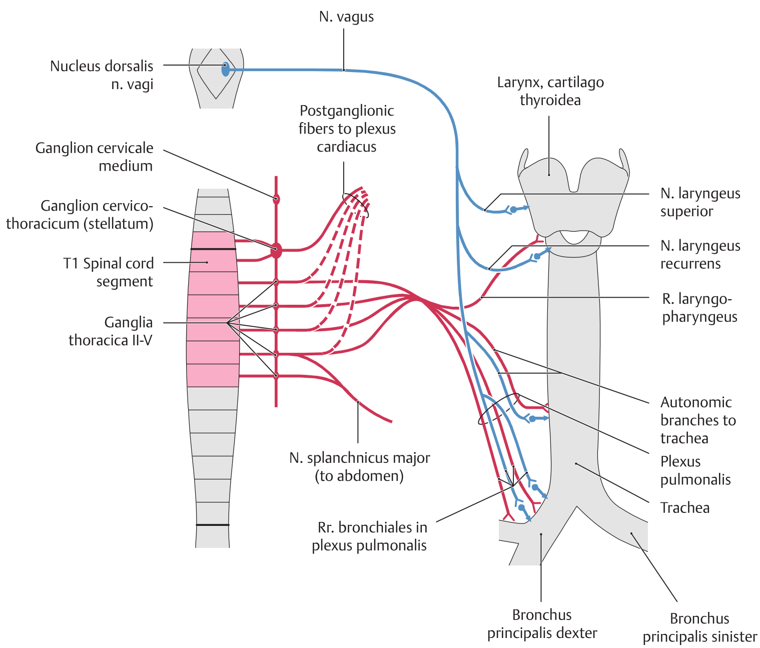


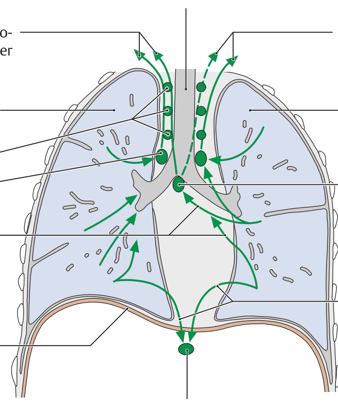
Fig. 8.27 **Autonomic innervation of the tracheobronchial tree**
Sympathetic innervation (red); parasympathetic innervation (blue).



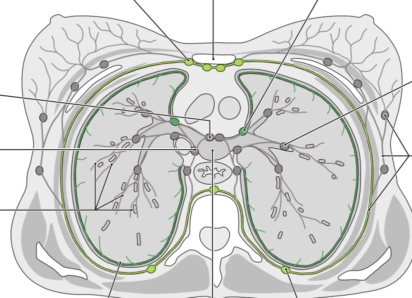
Lymphatics of the Pleural Cavity

The lungs and bronchi are drained by two lymphatic drainage systems. The peribronchial network follows the bronchial tree, draining lymph from the bronchi and most of the lungs. The subpleural network collects lymph from the peripheral lung and pleura visceralis.

Fig. 8.28 **Lymphatic drainage of the pleural cavity**
Transverse section, inferior view.

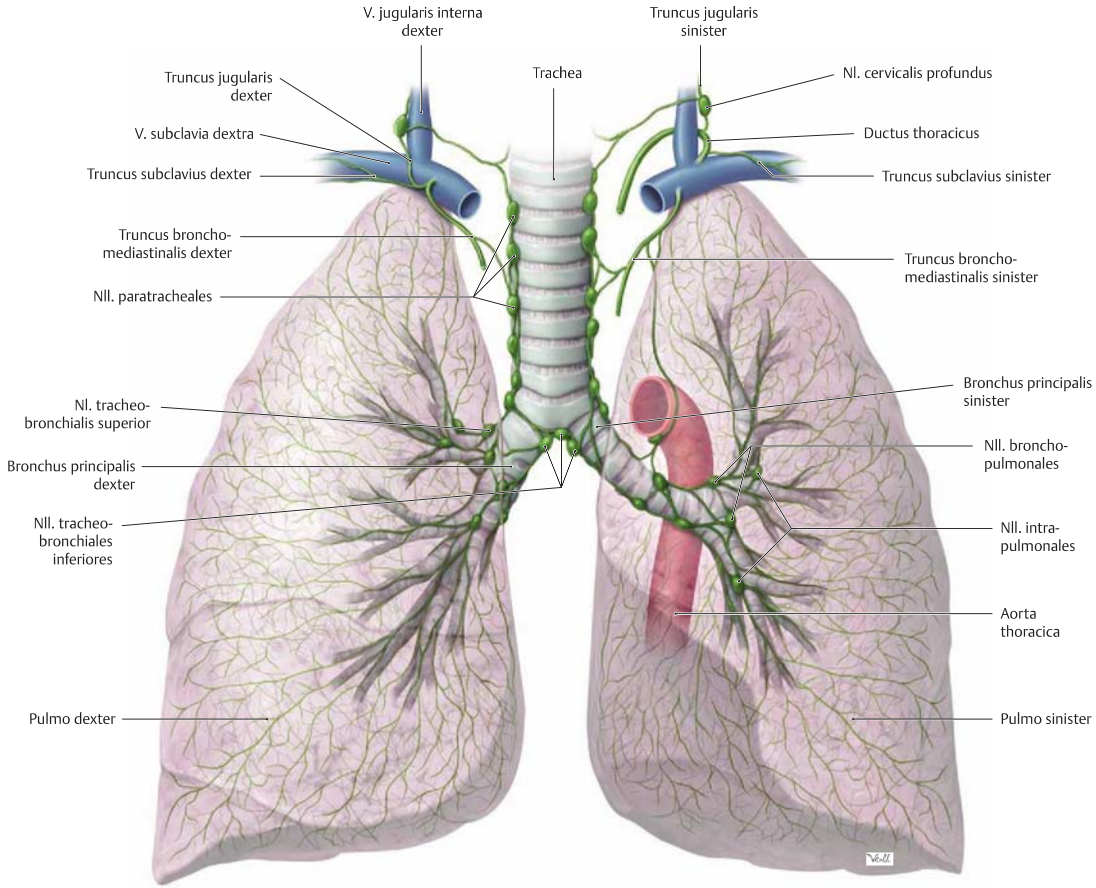


A Peribronchial network, coronal section. Nll. intrapulmonales along the bronchial tree drain lymph from the lungs into the nll. bronchopulmonales. Lymph then passes sequentially through the nll. tracheobronchiales inferiores and superiores, nll. paratracheales, truncus bronchomediastinalis, and finally to the ductus lymphaticus dexter or ductus thoracicus. *Note:* Significant amounts of lymph from the left lower lobe drain to the nll. tracheobronchiales superiores dextrae.



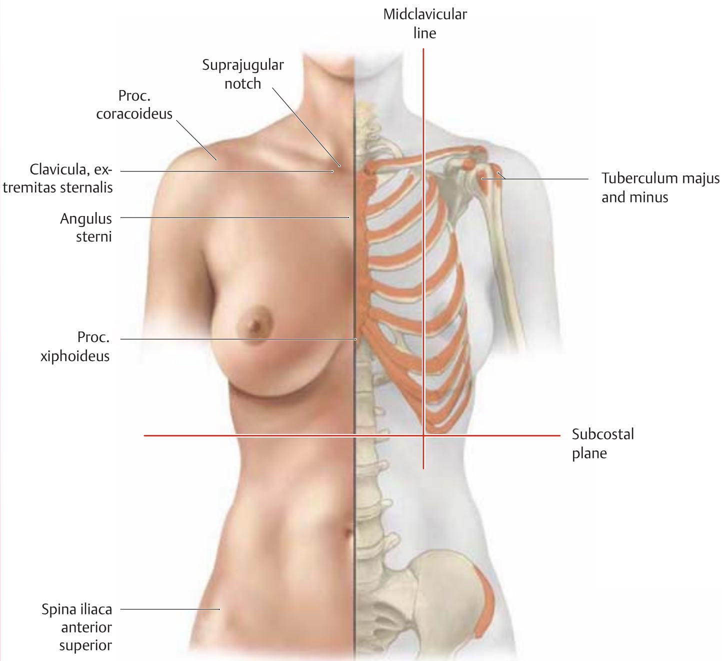
B Subpleural network, transverse section, superior view.

Fig. 8.29 Lymph nodes of the pleural cavity
Anterior view of pulmonary nodes.

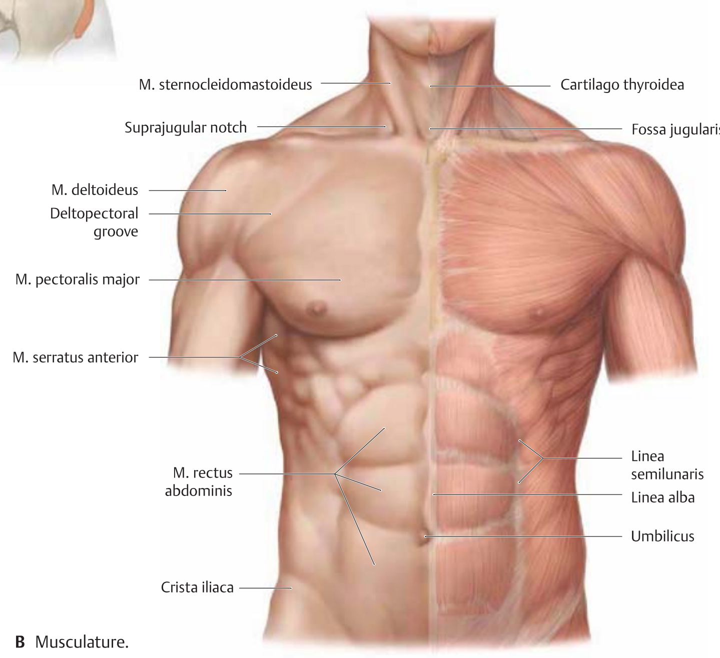


Surface Anatomy

Fig. 9.1 **Palpable structures in the thorax**
Anterior view. See pp. 40–41 for structures of the back.

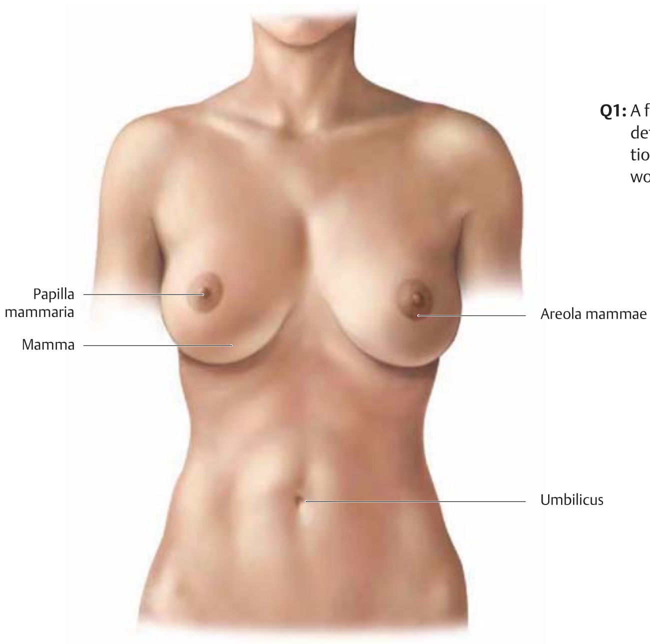


A Bony prominences.



B Musculature.

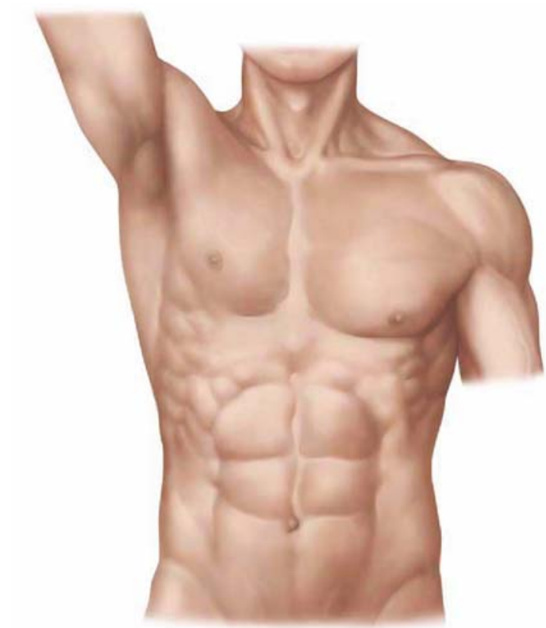
Fig. 9.2 Surface anatomy of the thorax
Anterior view. See pp. 40–41 for structures of the back.



A Female thorax.

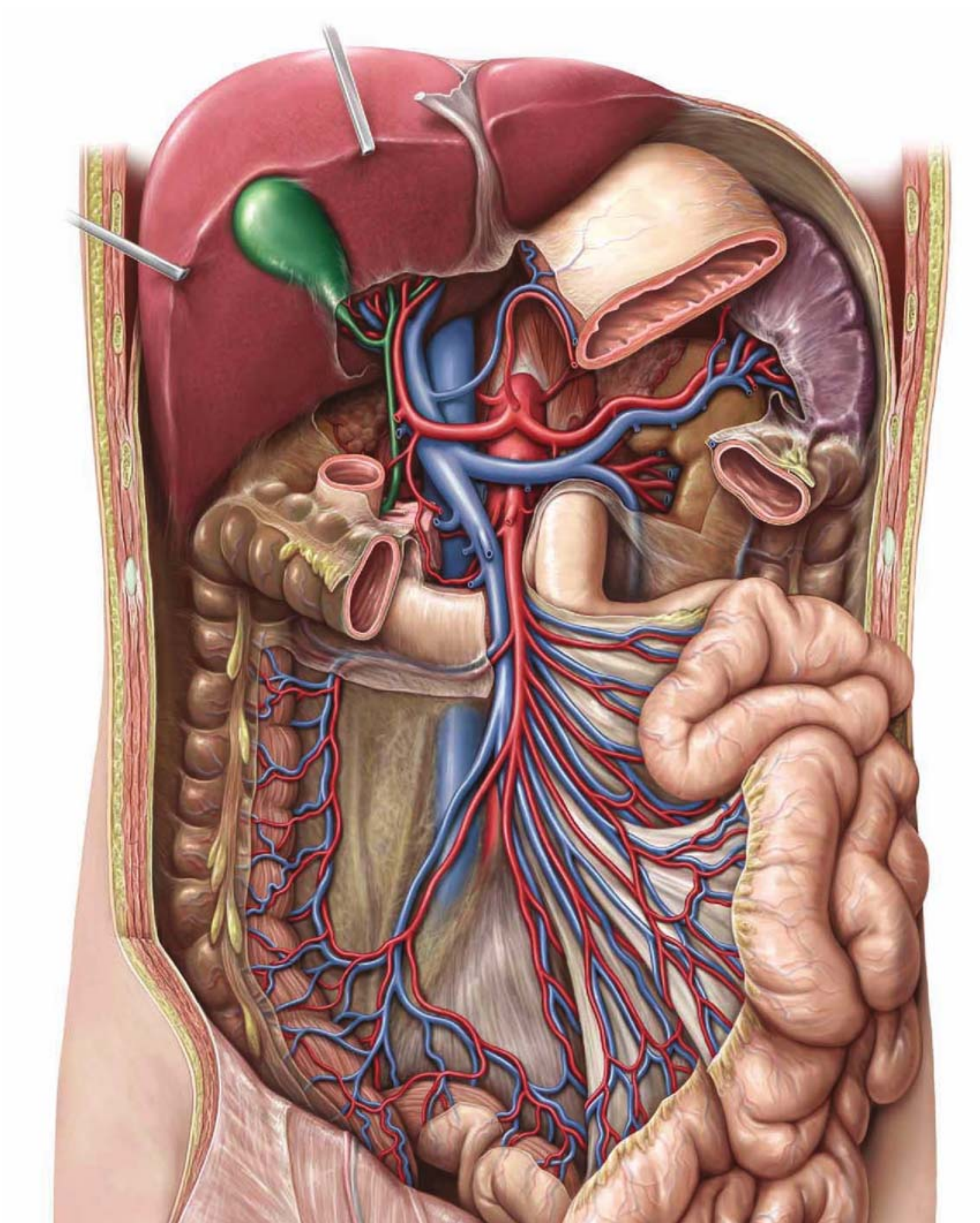
Q1: A female patient has given a history of detecting a "lump" during a self-examination. How would you proceed? Where would you palpate for lymph nodes?

Q2: You are presented with the anterior chest of your first hospital patient. How would you formulate a plan to optimally examine the four valves of the heart?



B Male thorax.

See answers beginning on p. 626.



Abdomen & Pelvis

Pelvic Girdle

Fig. 10.1 **Pelvic girdle**
Anterosuperior view. The pelvic girdle consists of the two os coxae and the sacrum (see p. 358).

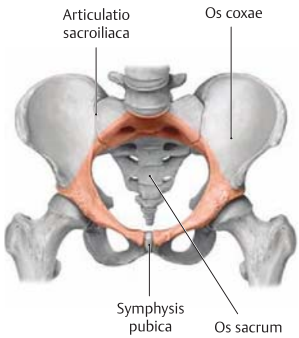
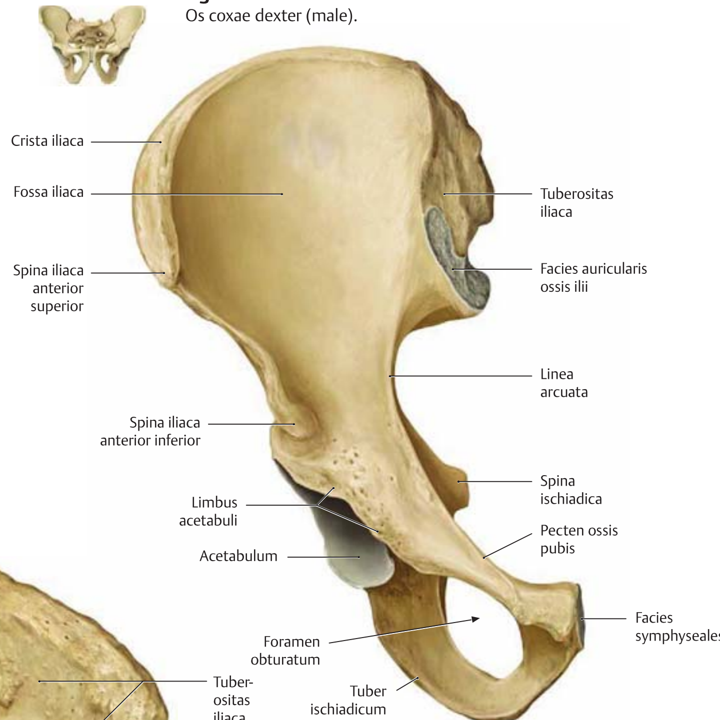
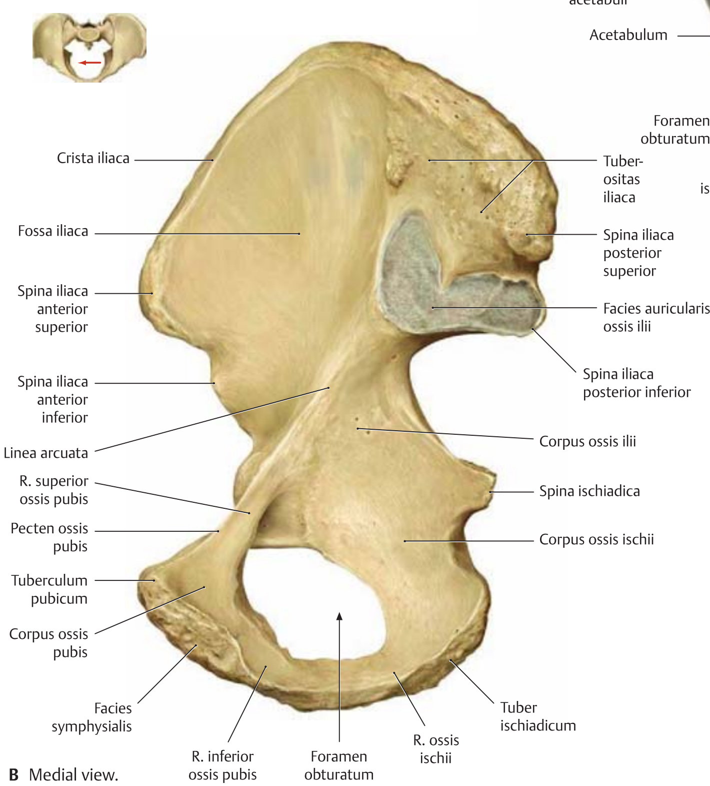


Fig. 10.2 **Os coxae**
Os coxae dexter (male).

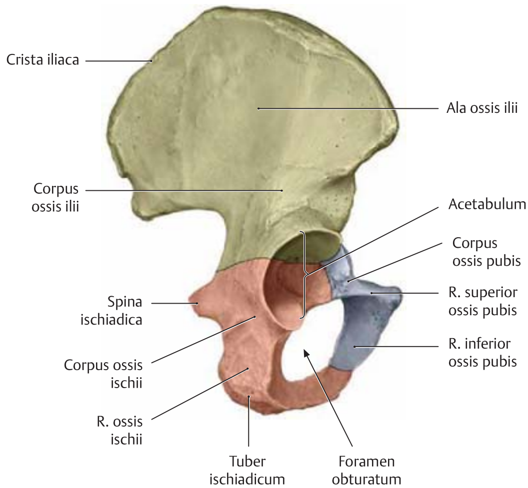


A Anterior view.

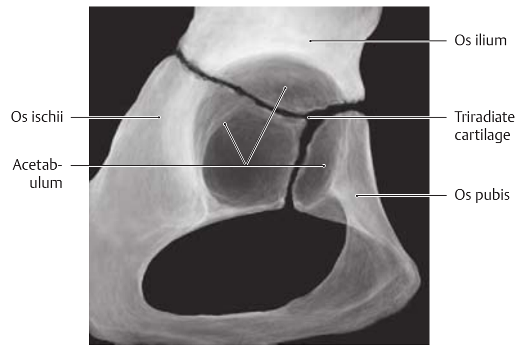


B Medial view.

Fig. 10.3 Triradiate cartilage of os coxae
Os coxae dexter, lateral view. Os coxae consists of the os ilium, os ischii, and os pubis.

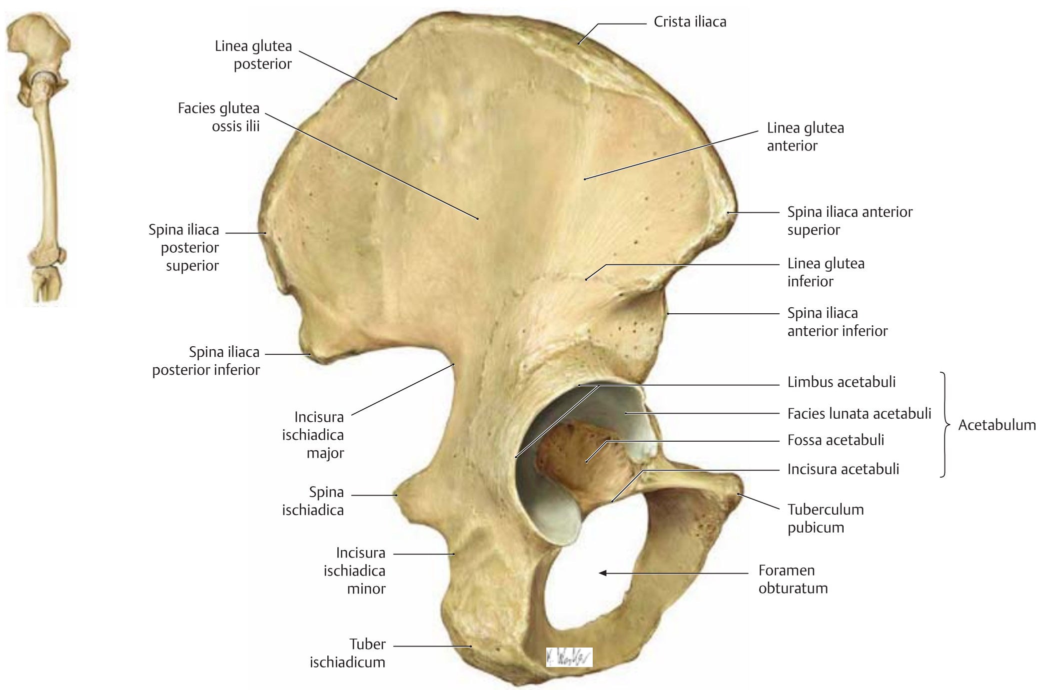


A Junction of the triradiate cartilage.



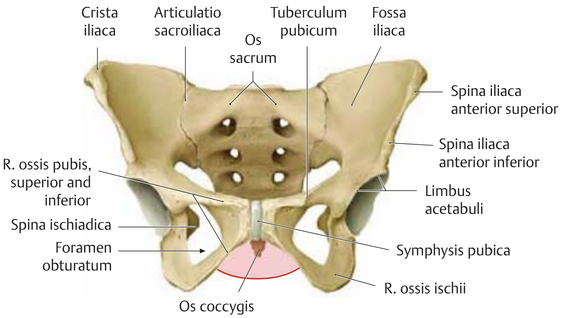
B Radiograph of a child's acetabulum. Os coxae dexter, lateral view.

Fig. 10.4 Os coxae: Lateral view
Right hip bone (male).

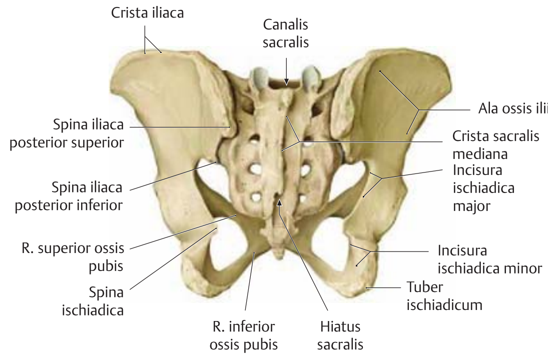


Male & Female Pelvis

Fig. 10.5 **Female pelvis**

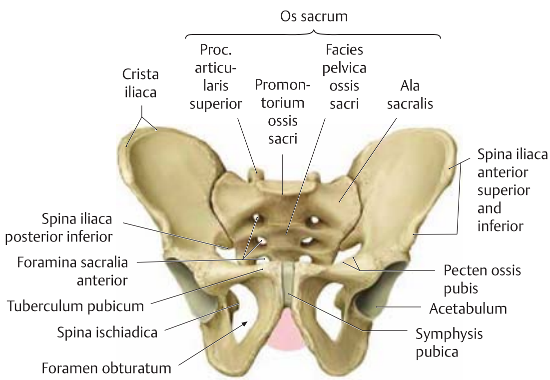


A Anterior view.

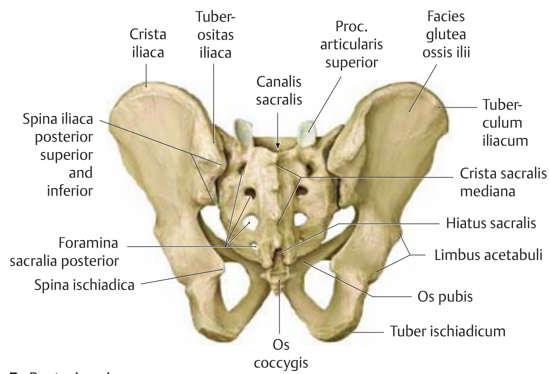


B Posterior view.

Fig. 10.6 **Male pelvis**

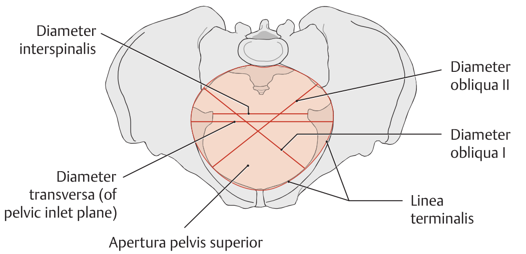


A Anterior view.

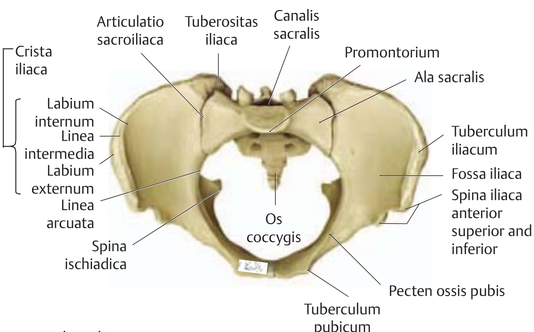


B Posterior view.

Fig. 10.7 Female pelvis: Superior view

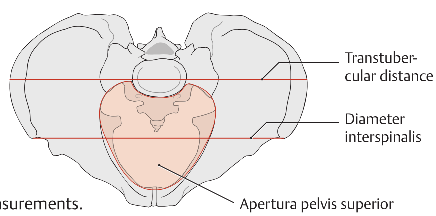


A Pelvic measurements.

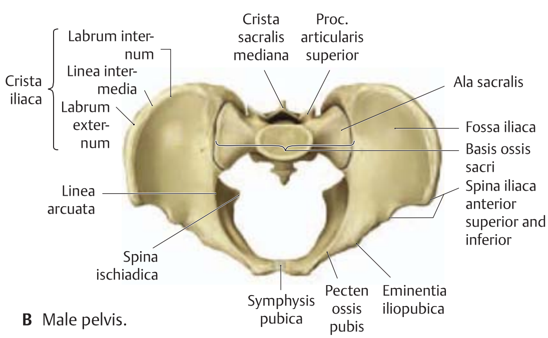


B Female pelvis.

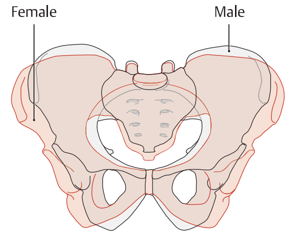
Fig. 10.8 Male pelvis: Superior view



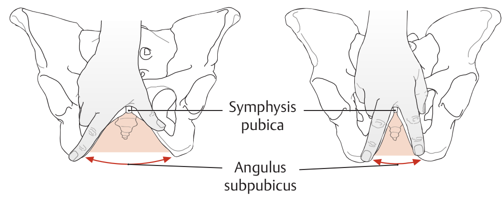
A Pelvic measurements.



B Male pelvis.



A Male and female pelvis.



B Female. **C** Male.

Table 10.1 Gender-specific features of the pelvis

Structure	Female	Male
Pelvis major	Wide and shallow	Narrow and deep
Aperatura pelvis superior	Transversely oval	Heart-shaped
Aperatura pelvis inferior	Roomy and round	Narrow and oblong
Tuber ischiadicum	Everted	Inverted
Cavitas pelvis	Roomy and shallow	Narrow and deep
Os sacrum	Short, wide, and flat	Long, narrow, and convex
Angulus subpubicus	90–100 degrees	70 degrees

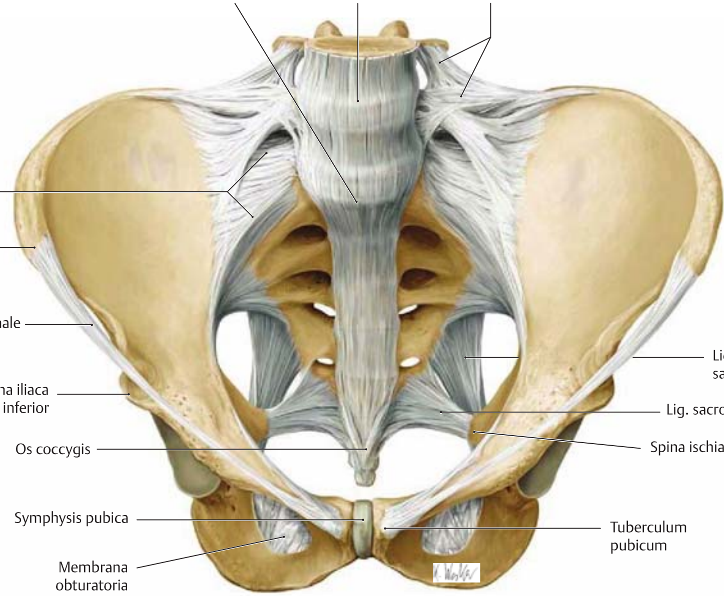
Clinical

Childbirth

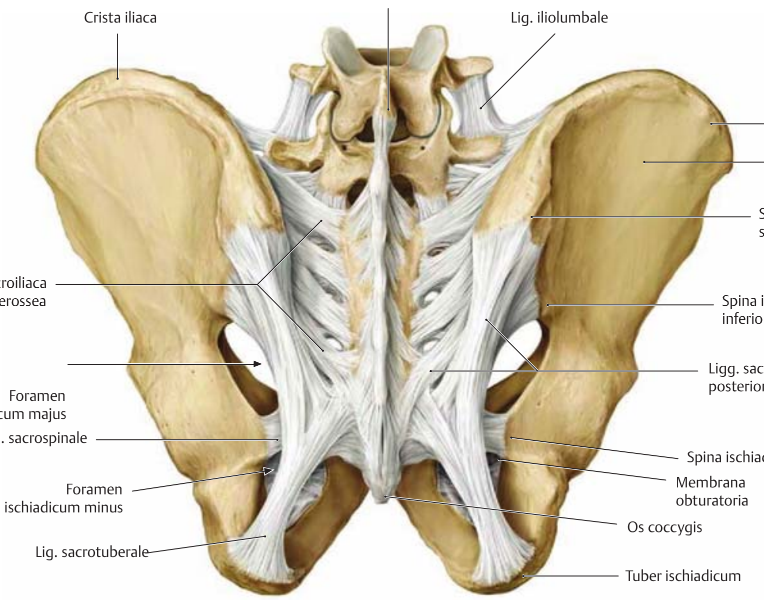
A non-optimal relation between the maternal pelvis and the fetal head may lead to complications during childbirth, potentially necessitating a caesarean section. Maternal causes include earlier pelvic trauma and innate malformations. Fetal causes include hydrocephalus (disturbed circulation of cerebrospinal fluid, leading to brain dilation and cranial expansion).

Pelvic Ligaments

Fig. 10.9 **Ligaments of the pelvis**
Male pelvis.

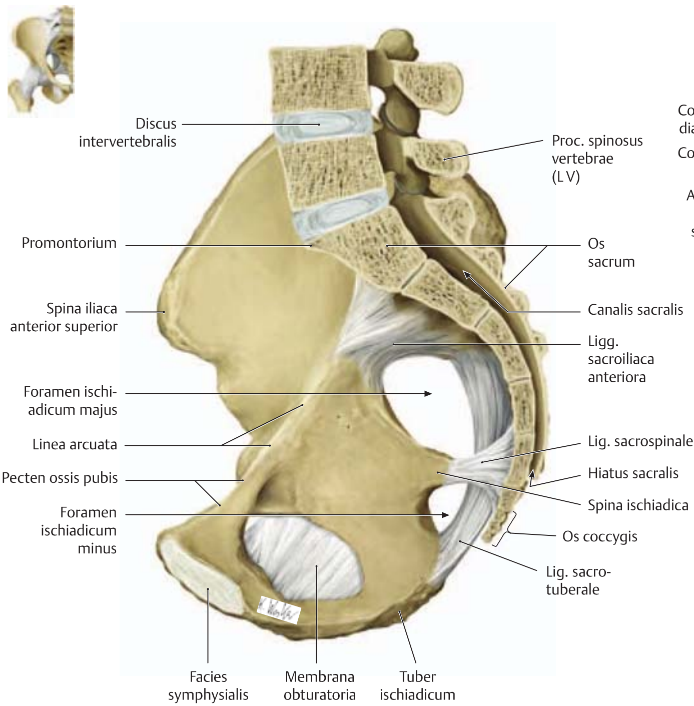


A Anterosuperior view.

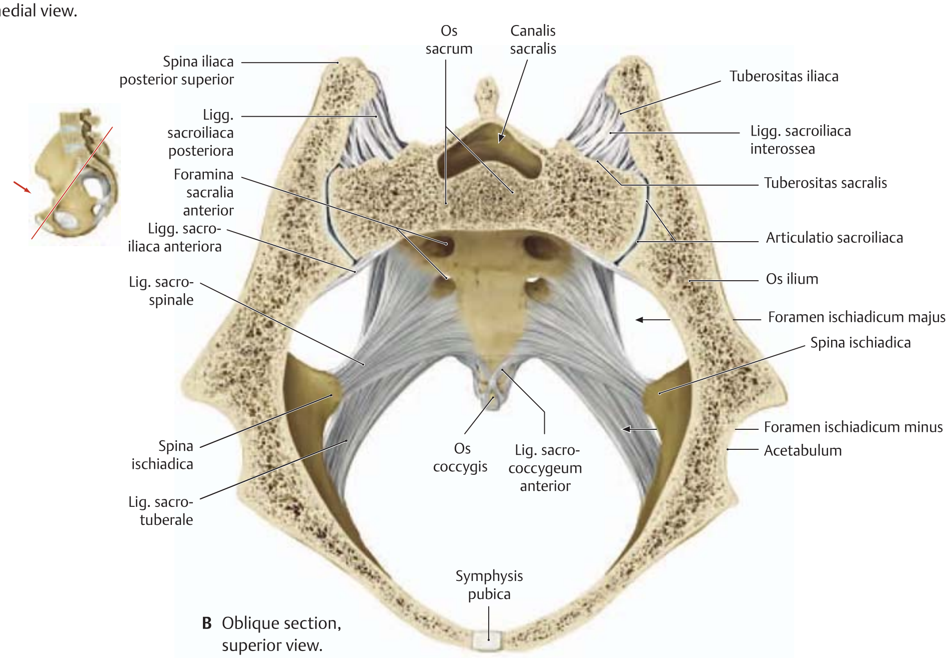


B Posterior view.

Fig. 10.10 **Ligaments of art. sacroiliaca**
Male pelvis.

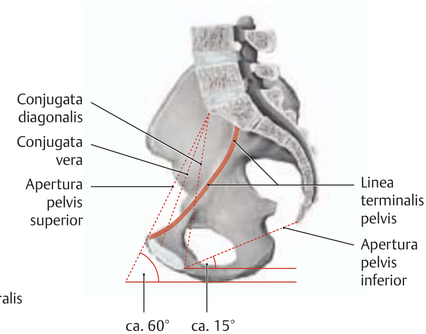


A Right half of pelvis, medial view.



B Oblique section, superior view.

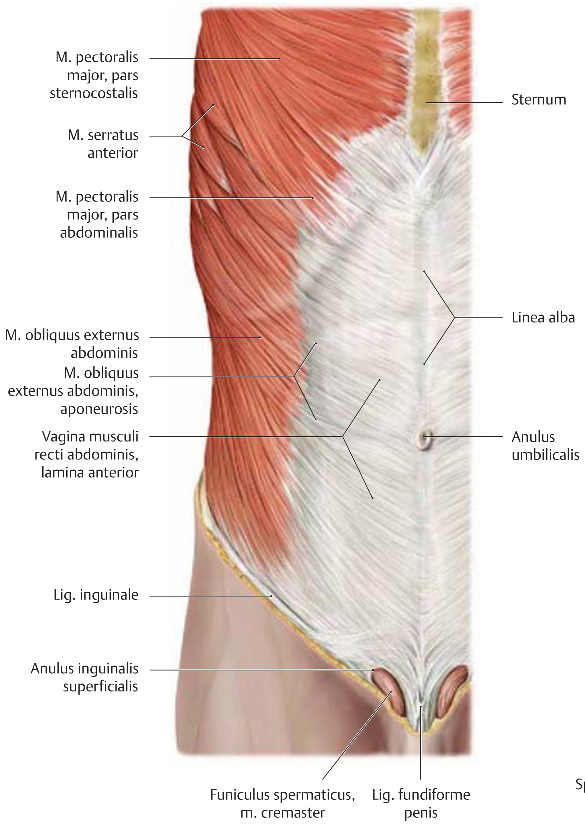
Fig. 10.11 **Pelvic measurements**
Right half of female pelvis, medial view.
See Table 10.1.



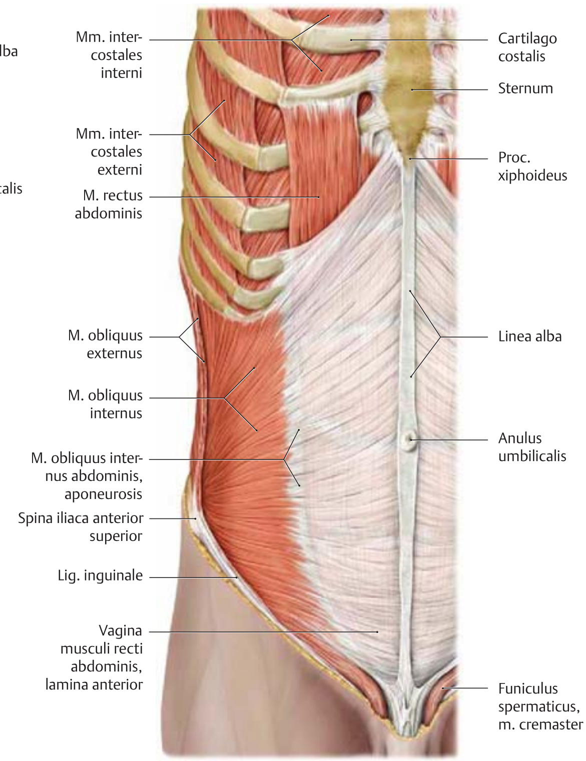
Muscles of the Abdominal Wall

The anterolateral muscles of the abdominal wall consist of m. obliquus externus abdominis, m. obliquus internus abdominis and m. transversus abdominis. The posterior or deep abdominal wall muscles (notably the m. psoas major) are functionally hip muscles (see p. 138).

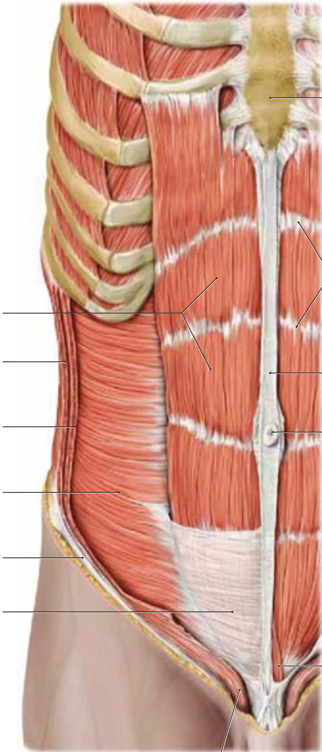
Fig. 11.1 **Muscles of the abdominal wall**
Right side, anterior view.



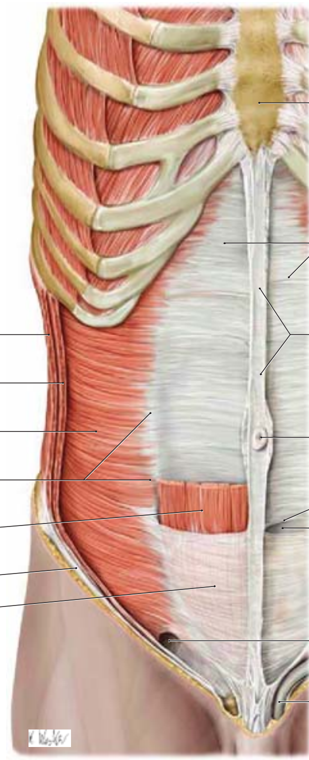
A Superficial abdominal wall muscles.



B *Removed:* M. obliquus externus abdominis, m. pectoralis major, and m. serratus anterior.



C *Removed:* M. obliquus internus abdominis.



D *Removed:* M. rectus abdominis.

Regio Inguinalis & Canalis Inguinalis

The regio inguinalis is the junction of the anterior abdominal wall and the anterior thigh. The canalis inguinalis is an important site for the passage of structures into and out of the abdominal cavity (e.g., components of funiculus spermaticus).

Fig. 11.2 **Inguinal region**
Right side, anterior view.

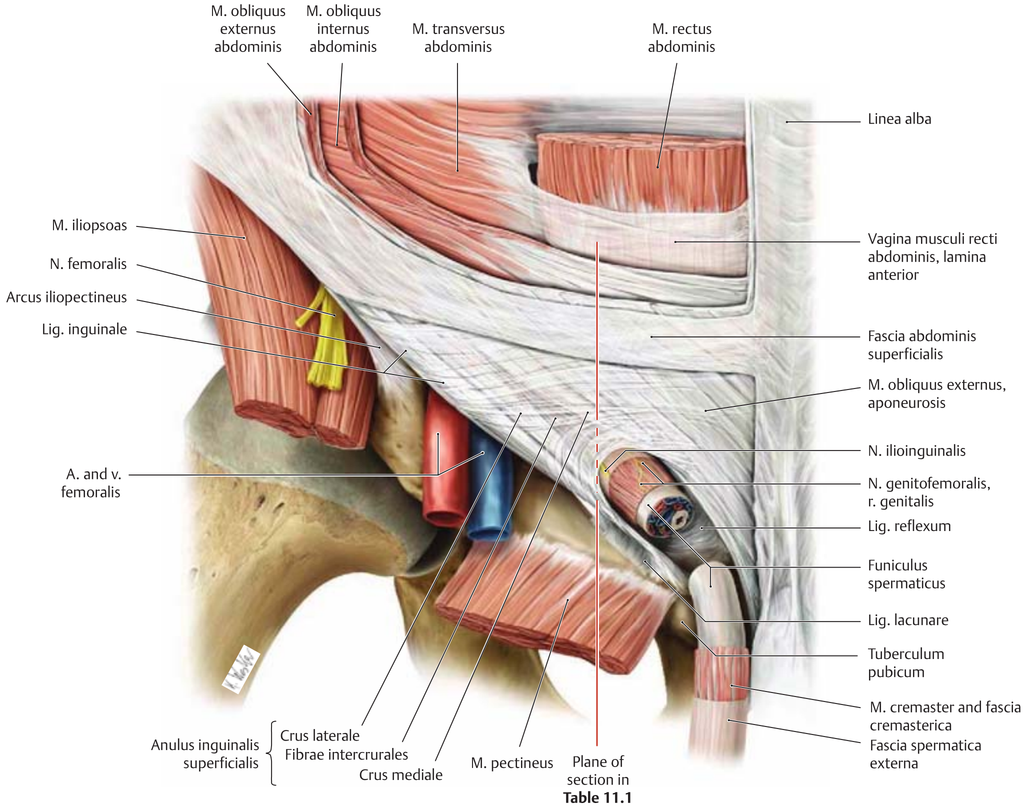


Table 11.1 Structures of the inguinal canal

Structures			Formed by
Wall	Anterior wall	①	M. obliquus externus abdominis aponeurosis
	Roof	②	M. obliquus internus abdominis
		③	M. transversus abdominis
	Posterior wall	④	Fascia transversalis
		⑤	Peritoneum parietale
	Floor	⑥	Lig. inguinale (densely interwoven fibers of the lower m.obliquus externus abdominis aponeurosis and adjacent fascia lata of thigh)
Openings	Anulus inguinalis superficialis		Opening in m. obliquus externus abdominis aponeurosis; bounded by crus mediale and laterale; intercrural fibers, and reflected lig. inguinale
	Anulus inguinalis profundus		Outpouching of the fascia transversalis lateral to the plica umbilicalis lateralis (vasa epigastrica inferiora)

Sagittal section through plane in Fig. 11.2.

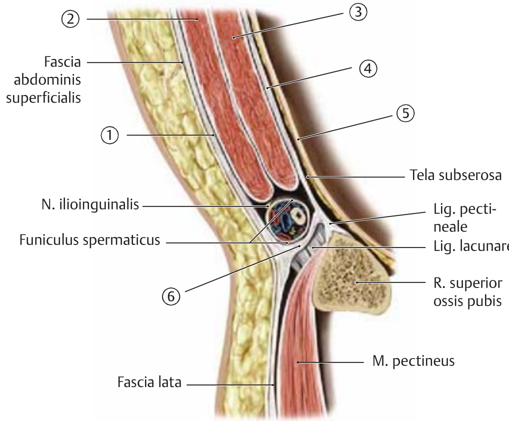
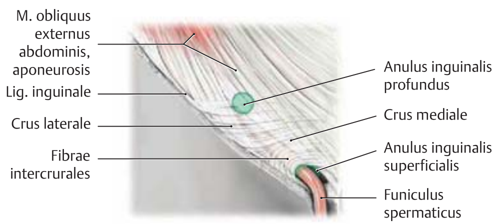
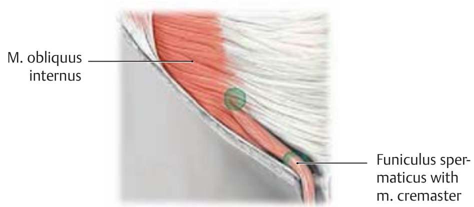


Fig. 11.3 Dissection of the regio inguinalis

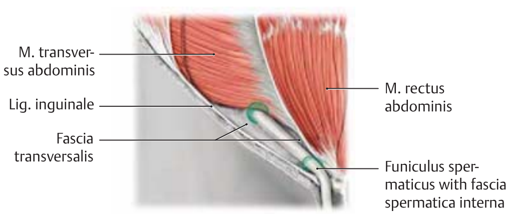
Right side, anterior view.



A Superficial layer.



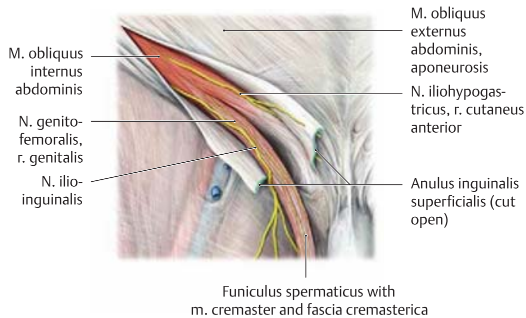
B *Removed:* Aponeurosis of m. obliquus externus abdominis.



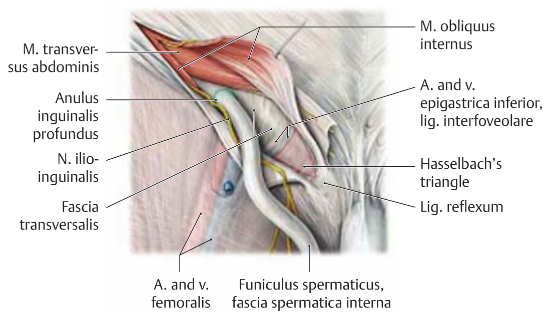
C *Removed:* M. obliquus internus abdominis.

Fig. 11.4 Opening of canalis inguinalis

Right side, anterior view.



A *Divided:* Aponeurosis of m. obliquus externus abdominis.

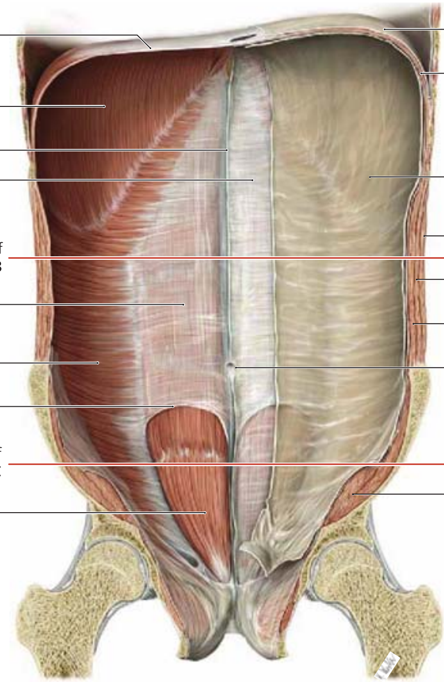


B *Divided:* M. obliquus internus abdominis and m. cremaster.

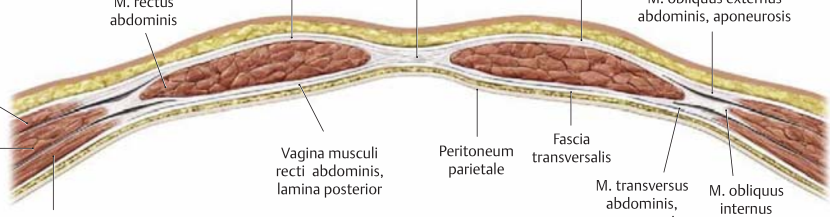
Abdominal Wall & Inguinal Hernias

The rectus sheath is created by fusion of the aponeuroses of m. transversus abdominis and mm. obliquus externus et infernus internus abdominis. The inferior edge of the posterior rectus sheath is called the linea arcuata.

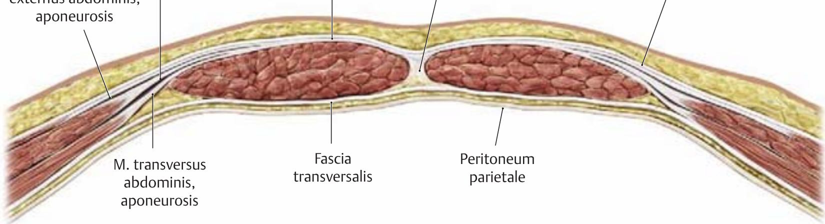
Fig. 11.5 **Abdominal wall and rectus sheath**



A Posterior (internal) view of the anterior abdominal wall.

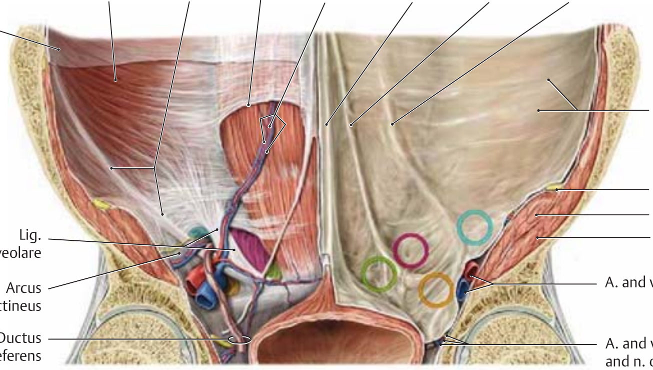


B Superior to arcuate line.



C Inferior to arcuate line.

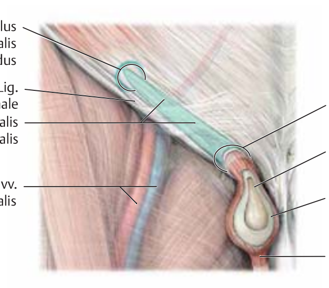
Fig. 11.6 Abdominal wall: Internal surface anatomy
Coronal section, posterior view. The three fossae of the anterior abdominal wall (*circled*) are sites of potential herniation.



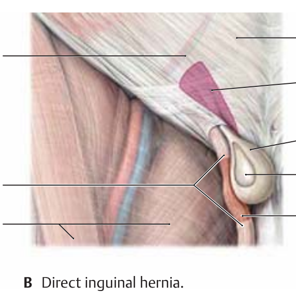
Clinical

Inguinal and femoral hernias

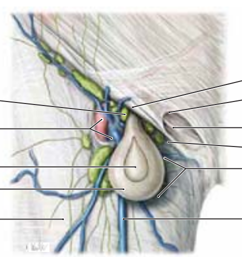
Indirect inguinal hernias occur in younger males and may be congenital or acquired; direct inguinal hernias are always acquired. Femoral hernias are acquired and more common in females.



A Indirect inguinal hernia.



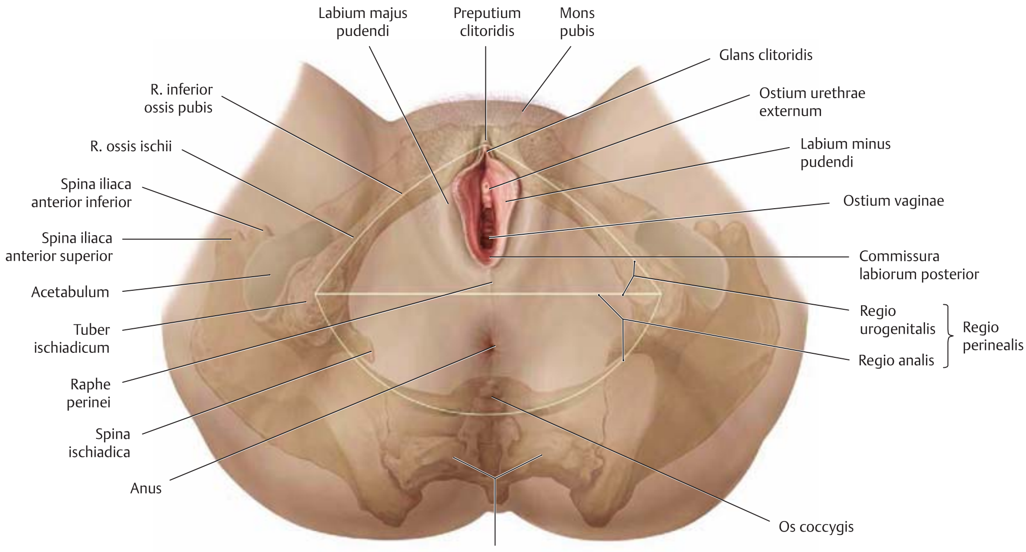
B Direct inguinal hernia.



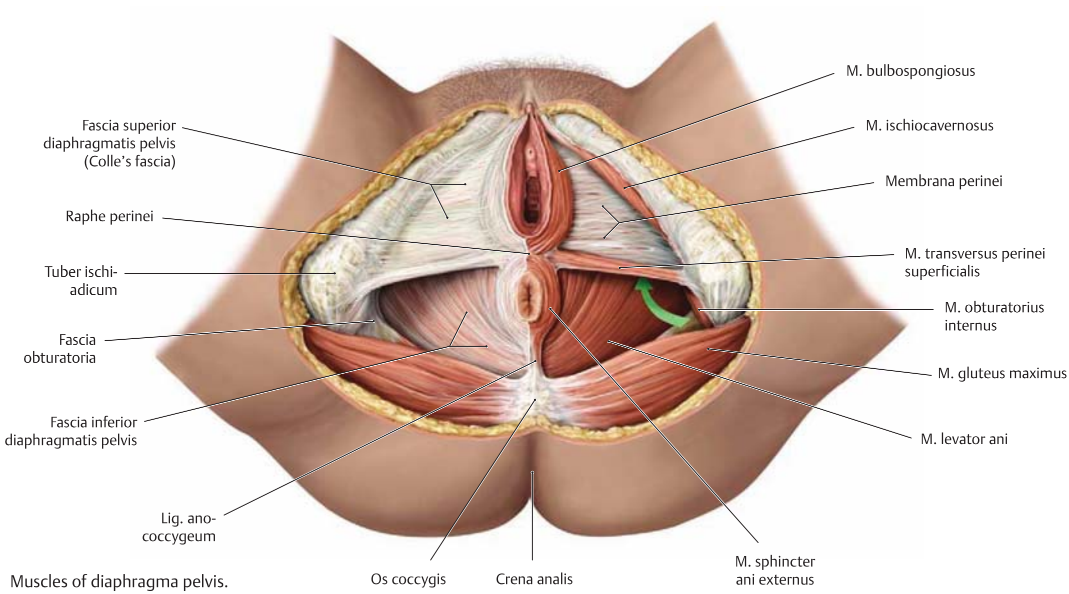
C Femoral hernia.

Regio Perinealis

***Fig. 11.7* Perineum and diaphragma pelvis: Female**
Lithotomy position, caudal (inferior) view. See p. 192 for the external genitalia.



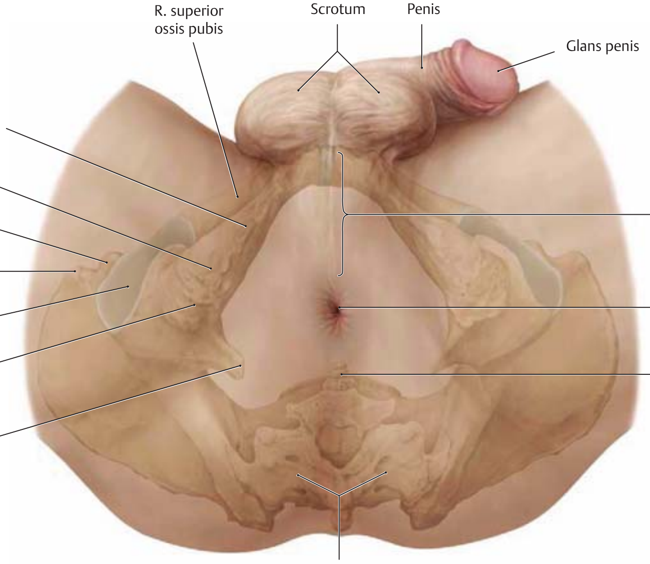
A Regio perinealis.



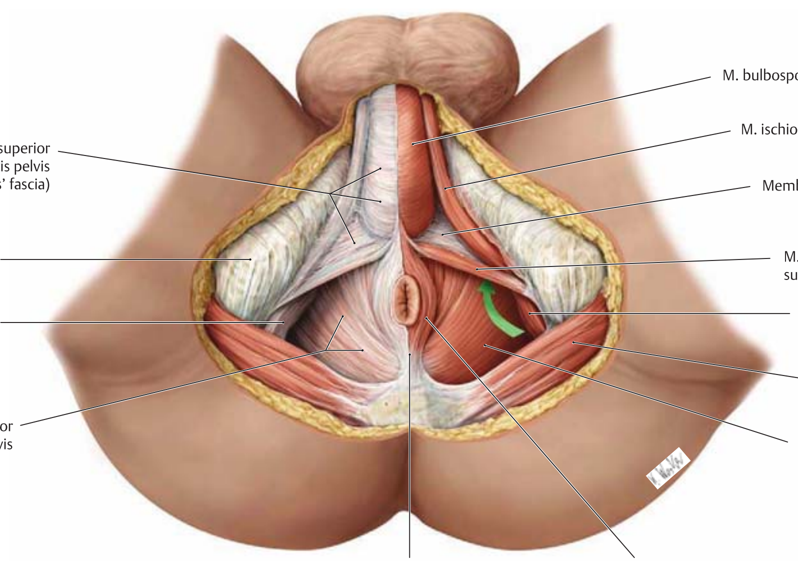
B Muscles of diaphragma pelvis.

The bilateral boundaries of the perineum in both sexes are the symphysis pubica, r. ischiopubicus, tuber ischiadicum, lig. sacrotuberale, and the coccyx. The green arrows indicate the anterior recess of fossa ischioanalis, superior to the urogenital muscles.

Fig. 11.8 Perineumand pelvic floor: Male
Lithotomy position, caudal (inferior) view. See p. 196 for the genitalia.



A Perineal region.



B Muscles of the pelvic floor.

Abdominal Wall Muscle Facts

Fig. 11.9 **Anterior muscles**
Anterior view.

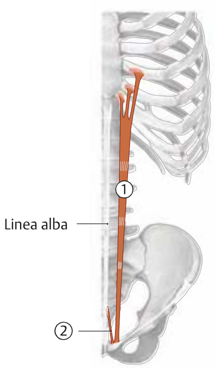
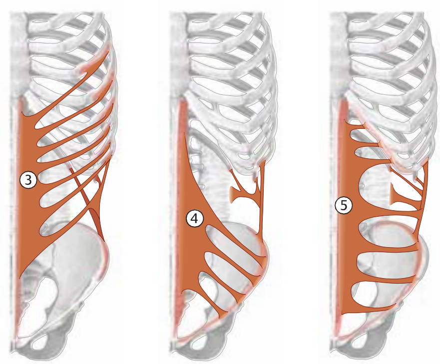


Fig. 11.10 **Anterolateral muscles**
Anterior view.



A M. obliquus externus abdominis.

B M. obliquus internus abdominis.

C M. transversus abdominis.

Fig. 11.11 **Posterior muscles**
Anterior view. M. psoas major and m. iliacus are together known as the m. iliopsoas.

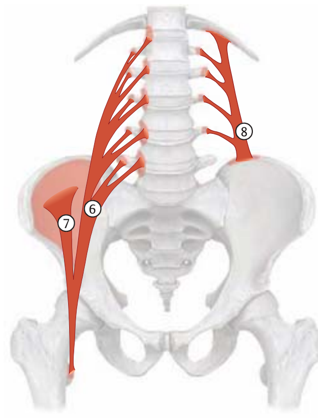
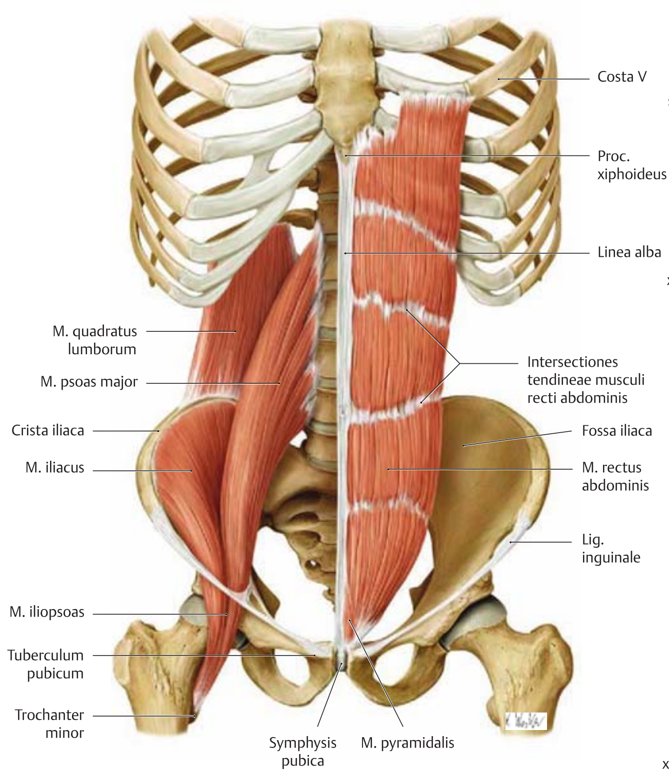


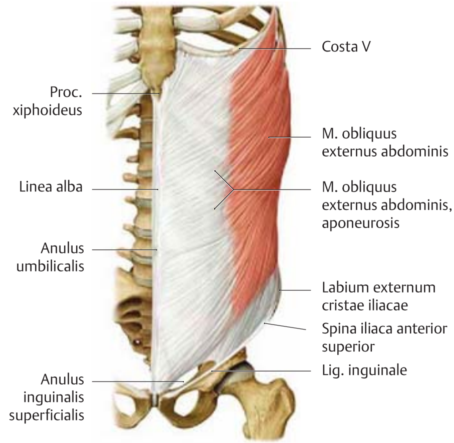
Table 11.2 **Abdominal wall muscles**

Muscle		Origin	Insertion	Innervation	Action
Anterior abdominal wall muscles					
① M. rectus abdominis		Os pubis (between tuberculum pubicum and symphyse)	Cartilago costalis of Costa V–VII, proc. xiphoideus of sternum	Nn. intercostales (T5–T12)	Flexes trunk, compresses abdomen, stabilizes pelvis
② M. pyramidalis		Os pubis (anterior to m. rectus abdominis)	Linea alba (runs within the vagina musculi recti abdominis)	N. subcostalis (12th N. intercostalis)	Tenses linea alba
Anterolateral abdominal wall muscles					
③ M. obliquus externus abdominis		Costa V–XII (outer surface)	Linea alba, tuberculum pubicum, anterior Sacra iliaca	Nn. intercostales (T7–T12)	*Unilateral:* Bends trunk to same side, rotates trunk to opposite side *Bilateral:* Flexes trunk, compresses abdomen, stabilizes pelvis
④ M. obliquus internus abdominis		Fascia thoracolumbalis (lamina profunda), crista iliaca (linea intermedia), spina iliaca anterior superior, fascia m. iliopsoas	Costa X–XII (lower borders), linea alba lamina anterior and posterior)	Nn. intercostales (T7–T12), N. iliohypogastricus, N. ilioinguinalis	
⑤ M. transversus abdominis		7th to 12th cartilago costalis (inner surfaces), fascia thoracolumbalis (lamina profunda), crista iliaca, spina iliaca anterior superior (labium internum), fascia M. iliopsoas	Linea alba, crista pubica		*Unilateral:* Rotates trunk to same side *Bilateral:* Compresses abdomen
Posterior abdominal wall muscles					
⑥ M. psoas major	Pars superficialis	T XII–L IV Corpus vertebrae and associated Discus intervertebralis (lateral surfaces)	Femur (trochanter minor), joint insertion as m. iliopsoas	Direct branches from plexus lumbalis (L2–L4)	Articulatio coxae: Flexion and external rotation lumbar spine (with femur fixed): *Unilateral:* Contraction bends trunk laterally *Bilateral:* Contraction raises trunk from supine position
	Pars profunda	L I–L V (Procc. costales)			
⑦ M. iliacus		Fossa iliaca		N. femoralis (L2–L4)	
⑧ M. quadratus lumborum		Crista iliaca and lig. iliolumbare (not shown)	Costa XII, L I–L IV corpus vertebrae (procc. transversi)	T12, L1–L4 Nn. spinales	*Unilateral:* Bends trunk to same side *Bilateral:* Bearing down and expiration, stabilizes Costa XII

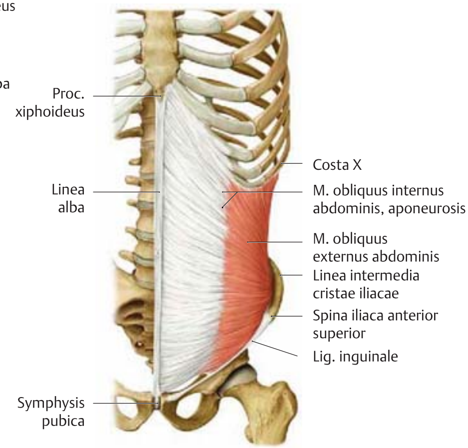
Fig. 11.12 Anterior and posterior abdominal wall muscles
Anterior view.



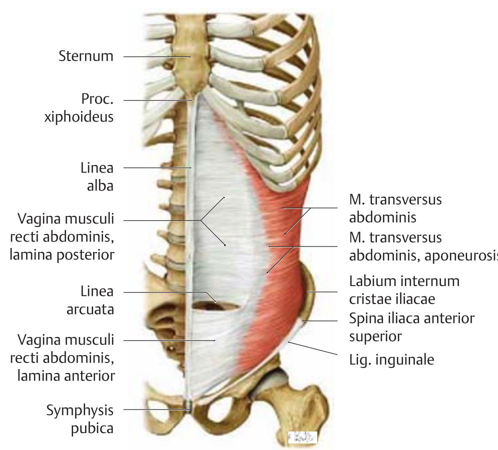
A Anterior and posterior muscles.



B M. obliquus externus abdominis.



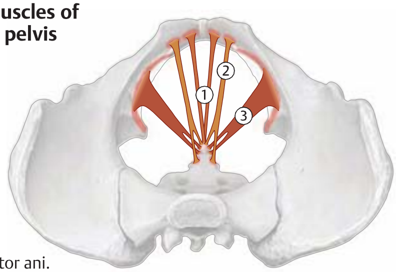
C M. obliquus internus abdominis.



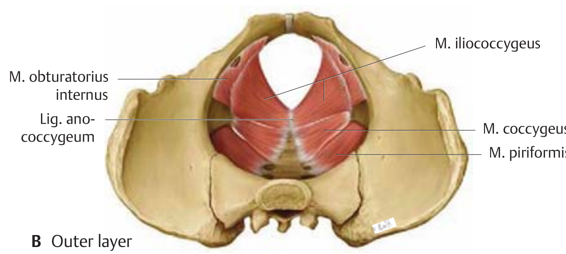
D M. transversus abdominis.

Diaphragma Pelvis Muscle Facts

Fig. 11.13 **Muscles of diaphragma pelvis**
Superior view.



A M. levator ani.



B Outer layer of diaphragma pelvis.

Table 11.3 **Muscles of the pelvic floor**

Muscle		Origin	Insertion	Innervation	Action
Muscles of the pelvic diaphragm					
M. levator ani	① M. puborectalis	R. pubis superior (both sides of symphysis pubica)	Lig. anococcygeum	Direct branches of plexus sacralis (S4), inferior anal n.	Diaphragma pelvis: Supports pelvic viscera
	② M. pubococcygeus	Os pubis (lateral to origin of m.puborectalis)	Lig. anococcygeum, os coccygis		
	③ M. iliococcygeus	Internal fascia of m. obturatorius internus of m. levator ani (tendinous arch)			
M. coccygeus		Os sacrum (inferior end)	Spina ischiadicum	Direct branches from plexus sacralis (S4–S5)	Supports pelvic viscera, flexes os coccygis
Muscles of the pelvic wall (parietal muscles)					
M. piriformis*		Os sacrum (facies pelvica)	Femur (apex of trochanter major)	Direct branches from plexus sacralis (S1–S2)	Articulatio coxae: External rotation, stabilization, and abduction of flexed hip
M. obturatorius internus*		Membrane of m.obturatorius internus and bony boundaries (inner surface)	Femur (trochanter major, medial surface)	Direct branches from plexus sacralis (L5–S1)	Articulatio coxae: External rotation and abduction of flexed hip
Sphincter and erector muscles					
④ M. sphincter ani externus		Encircles anus (runs posteriorly from perineum to lig. anococcygeum)		N. pudendus (S2–S4)	Closes anus
⑤ M. sphincter urethrae externus		Encircles urethra (division of m. transversus perinei profundus)			Closes urethra
⑥ M. bulbospongiosus		Runs anteriorly from perineum to clitoris (females) or raphe penis (males)			Females: Compresses glandula vestibularis major Males: Assists in erection
⑦ M. ischiocavernosus		R. ischiadicus	Crus clitoridis or crus penis		Maintains erection by squeezing blood into corpus cavernosum of clitoris or penis

*The piriformis and obturator internus areconsidered muscles of the hip (see p. 374).
The female and male external genitalia are shown on pp. 194, 203.

Fig. 11.14 **Sphincter and erector muscles of diaphragma pelvis**
Inferior view. See pp. 194, 203.

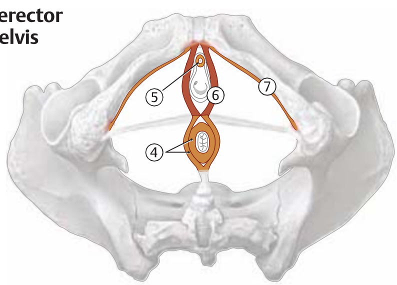
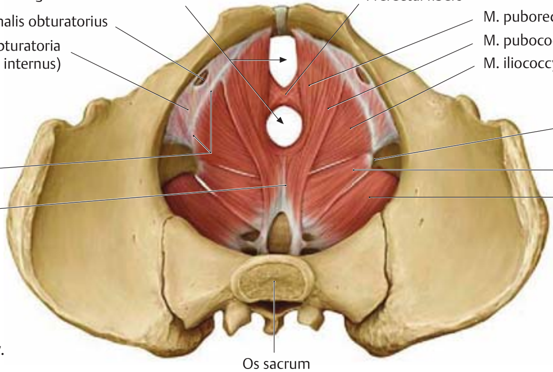
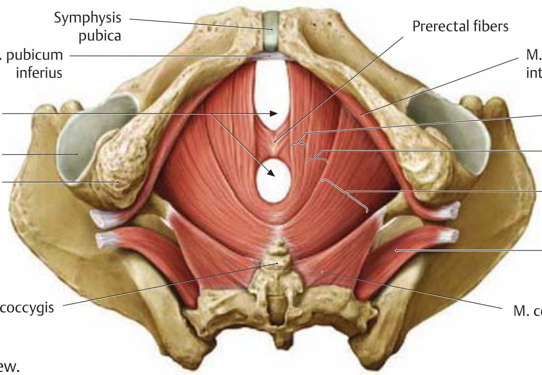


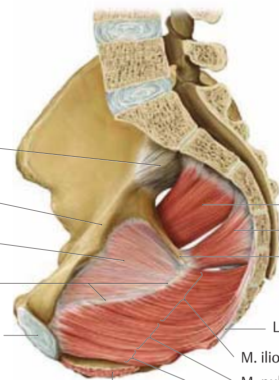
Fig. 11.15 **Diaphragma pelvis**
Female pelvis.



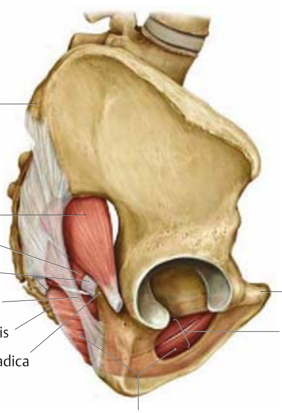
A Superior view.



B Inferior view.



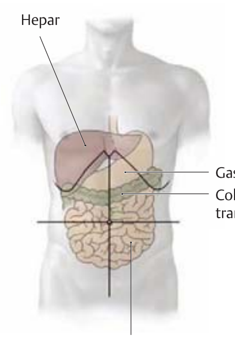
C Medial view of right hemipelvis.



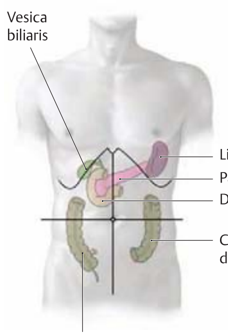
D Right lateral view.

Divisions of the Abdominopelvic Cavity

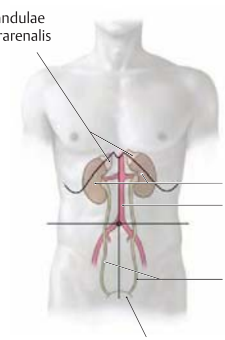
Fig. 12.1 **Organ layers and quadrants**
Anterior view. The organs of the abdomen and pelvis can be classified by layer, by quadrant (using the umbilicus at L4), by level (upper and lower abdomen, and pelvis), or with respect to the presence of mesenterium (Table 12.1).



A Anterior layer.



B Middle layer.



C Posterior layer.

Fig. 12.2 **Peritoneum and mesenterium**

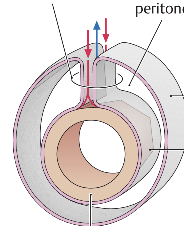
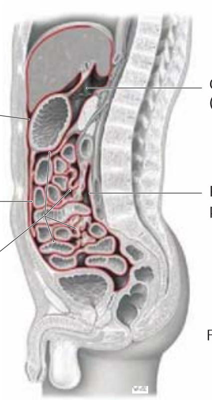


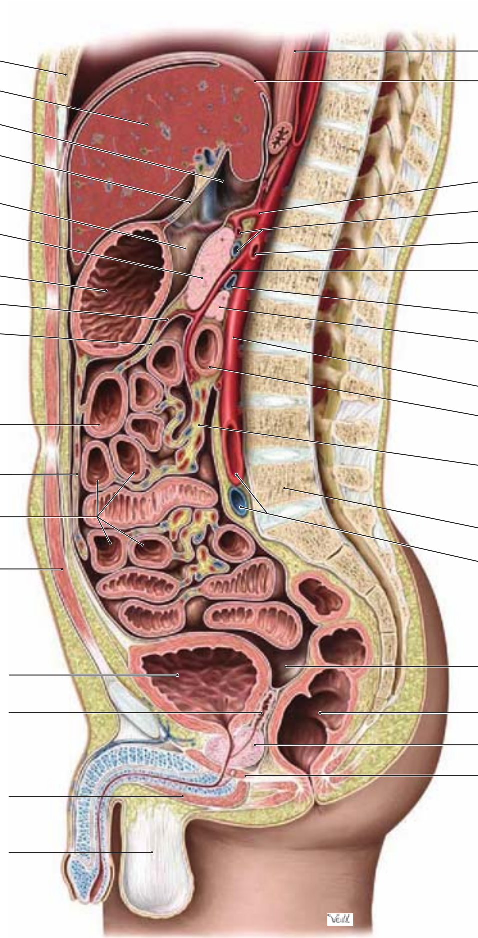
Table 12.1	**Organs of the abdomen and pelvis**			
Location		**Organs**		
Intraperitoneal organs: These organs have a mesenterium and are completely covered by the peritoneum.				
Cavitas peritonealis abdominalis		• Gaster • Intestinum tenue (jejunum, ileum, some of the pars superior of the duodenum) • Lien • Hepar		• Vesica biliaris • Caecum with appendix vermiformis (portions of variable size may be retroperitoneal) • Intestinum crassum (colon transversum and colon sigmoideum)
Cavitas peritonealis pelvis		• Uterus (fundus and corpus)	• Ovarium	• Tuba uterina
Extraperitoneal organs: These organs either have no mesenterium or lost it during development.				
Retroperitoneal	Primarily	• Ren	• Glandulae suprarenalis	• Cervix uteri
	Secondarily	• Duodenum (pars descendens, horizontalis, and ascendens) • Pancreas		• Colon ascendens and descendens • Rectum (upper 2/3)
Infraperitoneal/subperitoneal		• Vesica urinaria • Ureter distalis • Prostata	• Vesica seminalis • Cervix uteri	• Vagina • Rectum (lower 1/3)

Fig. 12.3 Peritoneal relationships

Midsagittal section through male pelvis, viewed from the left side.



A Peritoneal cavity. The peritoneum is shown in red.



B Organs of the abdomen and pelvis.

Clinical

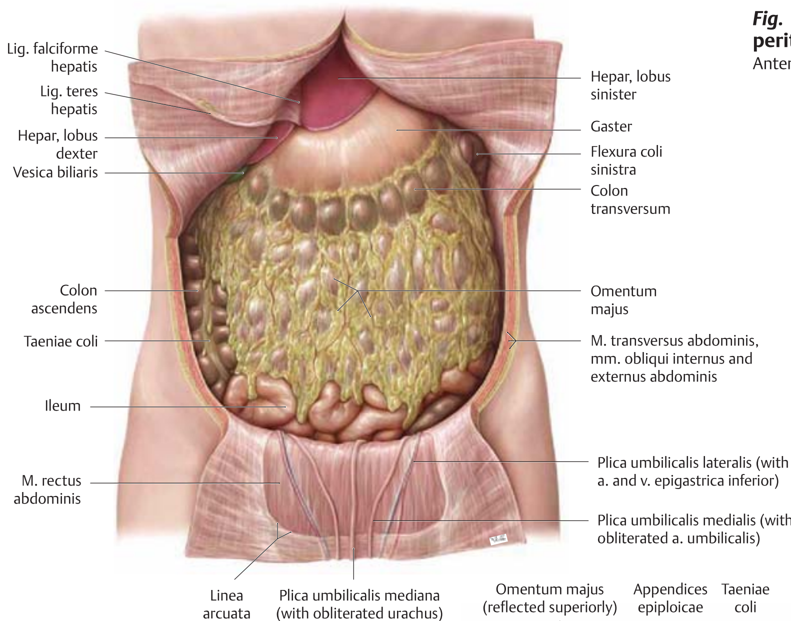
Acute abdominal pain

Acute abdominal pain ("acute abdomen") may be so severe that the abdominal wall becomes extremely sensitive to touch ("guarding") and the intestines stop functioning. Causes include organ inflammation such as appendicitis, perforation due to a gastric ulcer (see p. 159), or organ blockage by a stone, tumor, etc. In women, gynecological processes or ectopic pregnancies may produce severe abdominal pain.

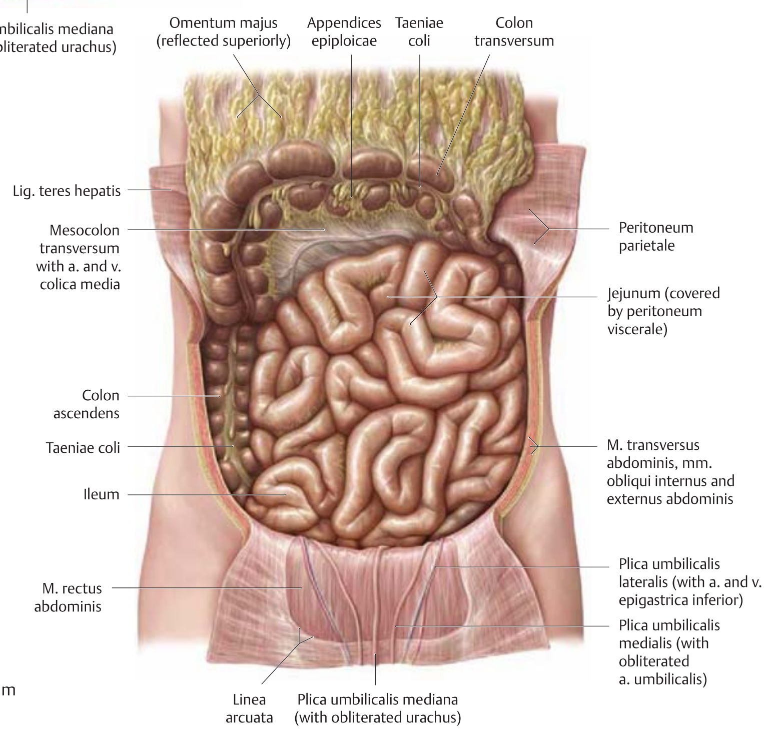
Cavitas Peritonealis & Greater Sac

The largest part of the peritoneal cavity is the greater sac. The omentum majus is an apron-like fold of peritoneum suspended from curvatura major of gaster and covering the anterior surface of colon transversum. The colon transversum divides the peritoneal cavity into a supracolic compartment (hepar, vesica biliaris, and gaster) and an infracolic compartment (intestines).

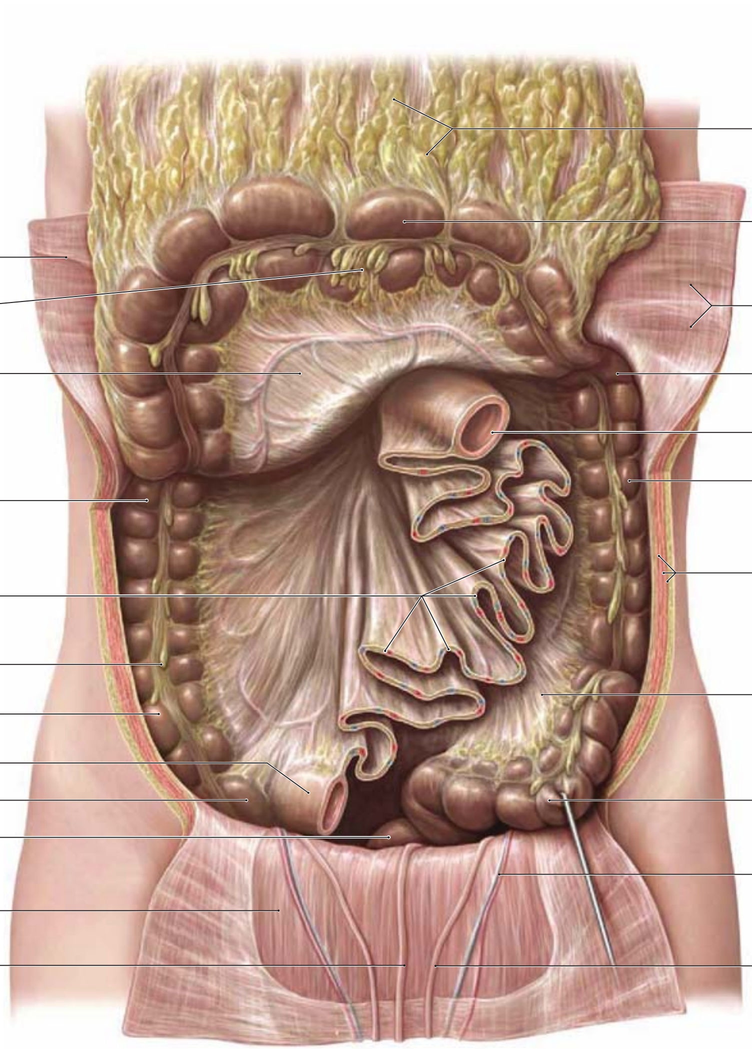
Fig. 12.4 **Dissection of the cavitas peritonealis**
Anterior view.



A Greater sac. *Retracted:* Abdominal wall.



B Infracolic compartment. *Reflected:* Omentum majus and colon transversum.

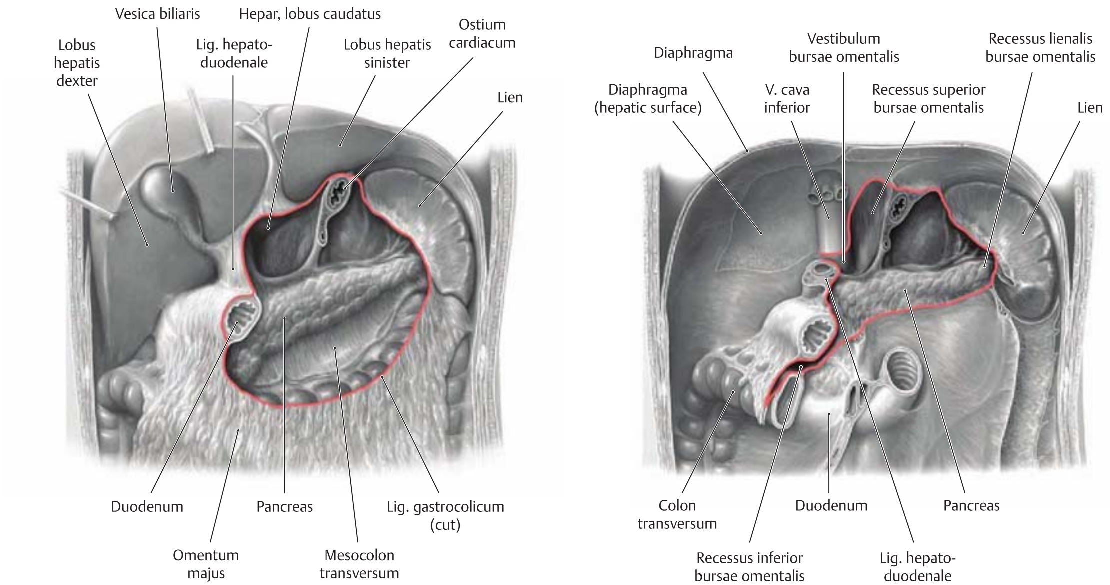


C Mesenterium. *Reflected:* Omentum majus and colon transversum. *Removed:* Intraperitoneal intestinum tenue.

Bursa Omentalis

Fig. 12.5 Bursa omentalis (lesser sac)

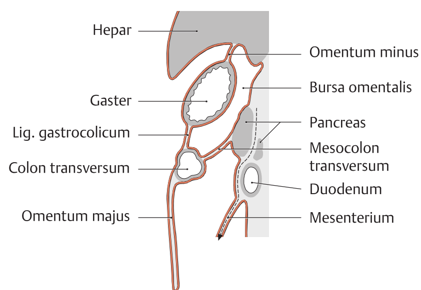
Anterior view. Bursa omentalis is the portion of the peritoneal cavity located behind omentum minus and gaster.



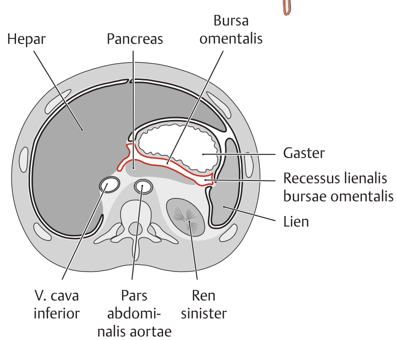
A Boundaries of bursa omentalis (omental bursa).

B Posterior wall of bursa omentalis.

Fig. 12.6 Location of bursa omentalis



A Sagittal section.



B Transverse section, inferior view.

Table 12.2 **Boundaries of the bursa omentalis (lesser sac)**

Direction	Boundary	Recess
Anterior	Omentum minus, lig. gastrocolicum	—
Inferior	Mesocolon transversum	Recessus inferior
Superior	Hepar (with lobus caudatus)	Recessus superior
Posterior	Pancreas, aorta (pars abdominalis), truncus coeliacus, a./v. lienalis, lig. gastrosplenicum, glandula suprarenalis sinister, ren sinister (extremitas superior)	—
Right	Hepar, bulbus duodeni	—
Left	Lien, lig. gastrosplenicum	Recessus lienalis

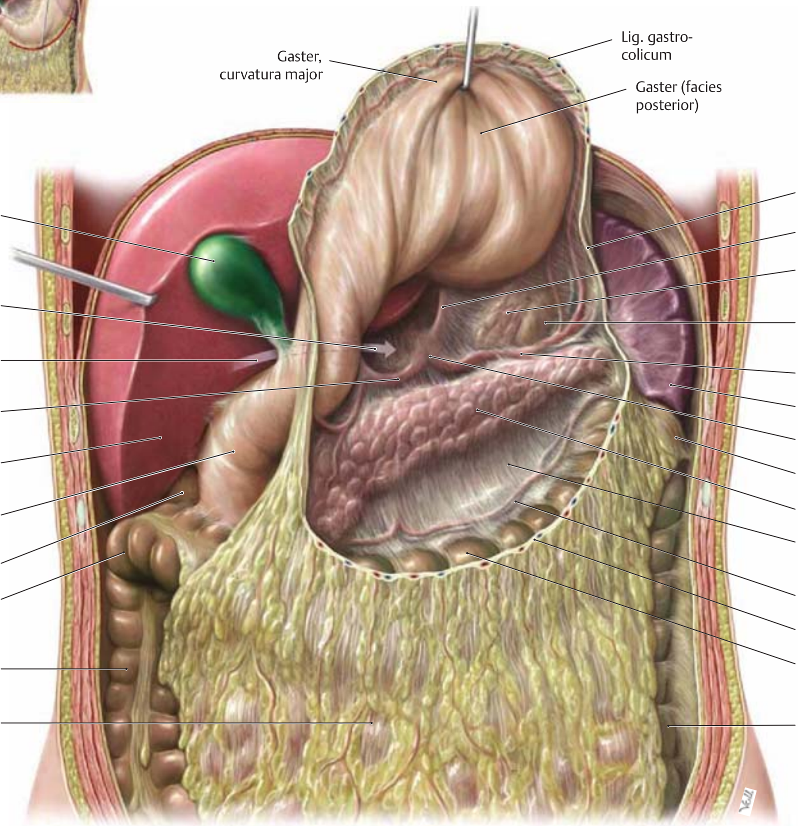


Fig. 12.7 **Bursa omentalis in situ**
Anterior view. *Divided:* Lig. gastrocolicum. *Retracted:* Hepar. *Reflected:* Gaster.

Table 12.3	**Boundaries of the foramen omentale**
The communication between the cavitas peritonealis and bursa omentalis is the foramen omentale (epiploicum) (see arrow in Fig. 12.7).	
Direction	**Boundary**
Anterior	Lig. hepatoduodenale with the v. portae, a. hepatica propria, and ductus choledochus
Inferior	Duodenum (pars superior)
Posterior	Vena cava inferior, diaphragma (crus dexter)
Superior	Hepar (lobus caudatus)

Mesenterium & Posterior Wall

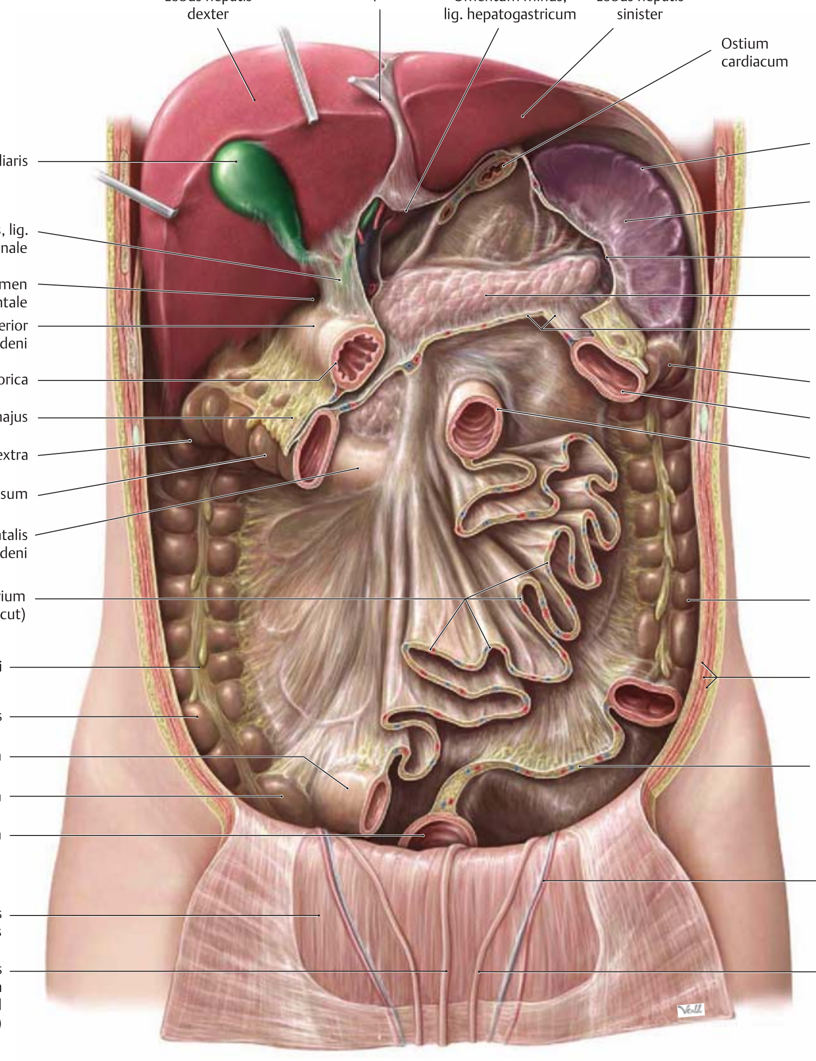


Fig. 12.8 **Mesenterium and organs of the cavitas peritonealis**
Anterior view. *Removed:* Gaster, jejunum, and ileum. *Reflected:* Hepar.

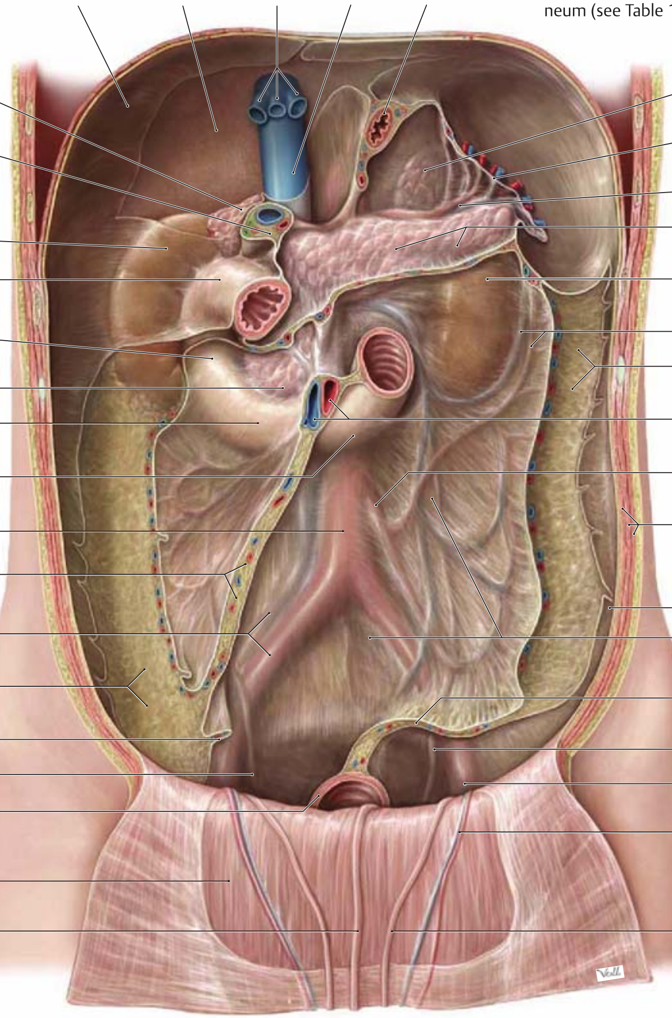


***Fig. 12.9* Posterior wall of the cavitas peritonealis**
Anterior view. *Removed:* All intraperitoneal organs. *Revealed:* Structures of the retroperitoneum (see Table 12.4 and p. 180).

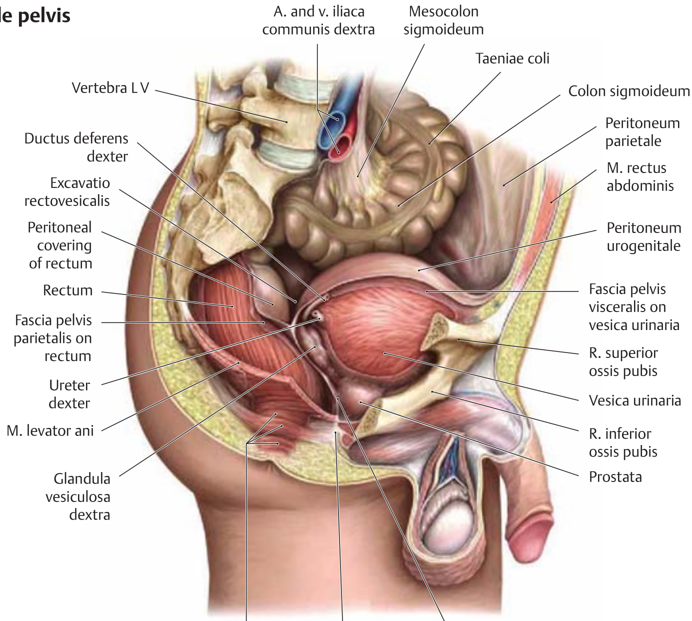
Table 12.4 Structures of the retroperitoneum

See pp. 216, 228, 239 for neurovascular structures of the retroperitoneum.

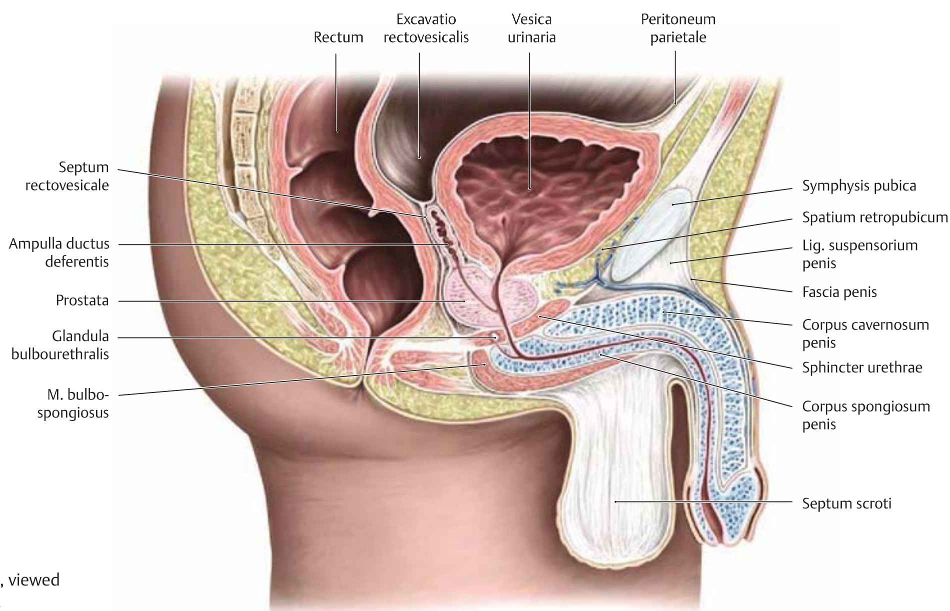
Classification	Organs	Vessels	Nerves
Primarily retroperitoneal (Retroperitoneal when formed)	• Ren • Glandula suprarenalis • Ureter	• Aorta (pars abdominalis) • Vena cava inferior and tributaries • Vv. lumbalis ascendens • V. portae and tributaries • Nodi lymphatici lumbales, sacrales and iliaci • Trunci lumbales and cisterna chyli	• Plexus lumbalis branches ∘ N. iliohypogastricus ∘ N. ilioinguinalis ∘ N. genitofemoralis ∘ N. cutaneus femoris lateralis ∘ N. femoralis ∘ N. obturatorius • Truncus sympathicus • Autonomic ganglia and plexi
Secondarily retroperitoneal (Mesenterium lost during development)	• Pancreas • Duodenum (pars descendens and horizontalis; some of pars ascendens) • Colon ascendens and descendens • Caecum (portions; variable) • Rectum (upper 2/3)		

Contents of the Pelvis

Fig. 12.10 **Male pelvis**

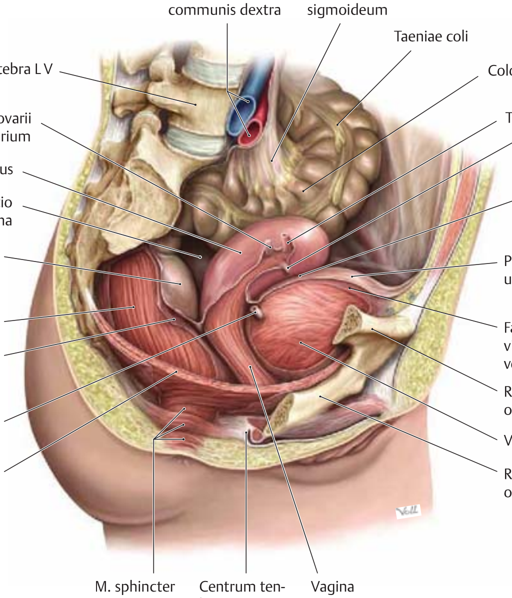


A Parasagittal section, viewed from the right side.

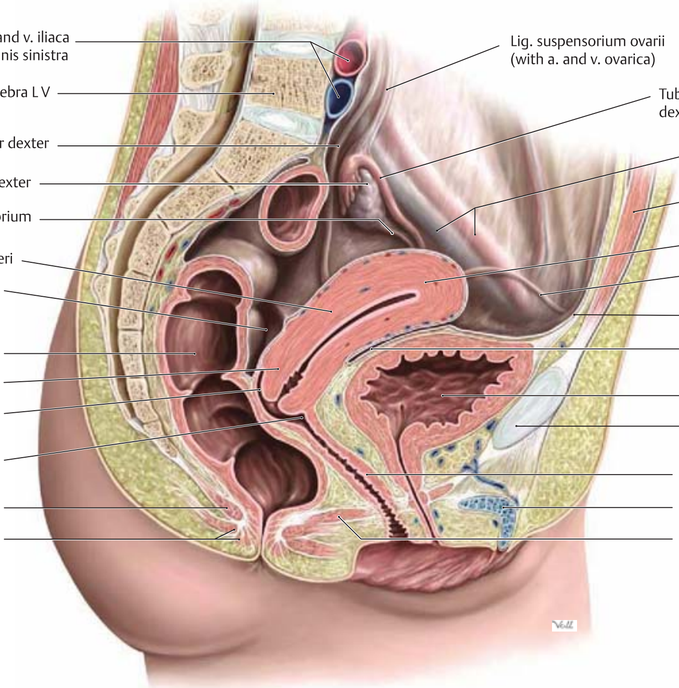


B Midsagittal section, viewed from the right side.

Fig. 12.11 Female pelvis



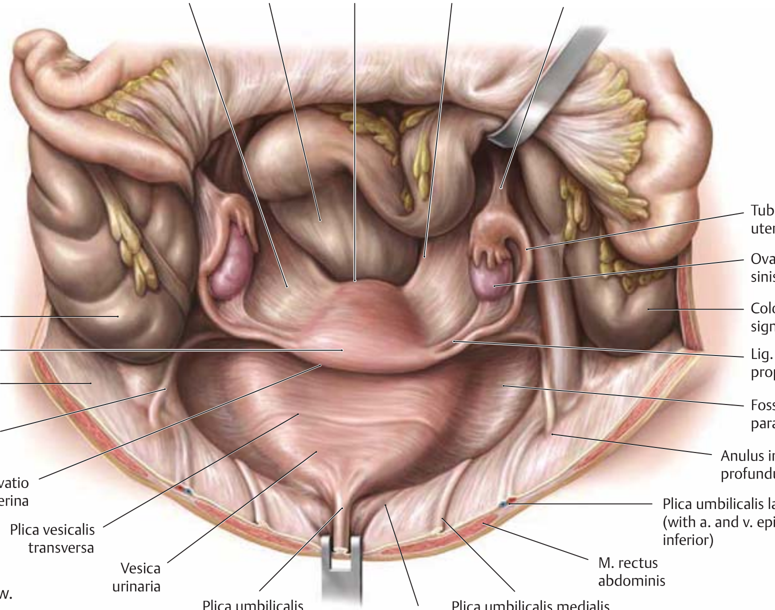
A Parasagittal section, viewed from the right side.



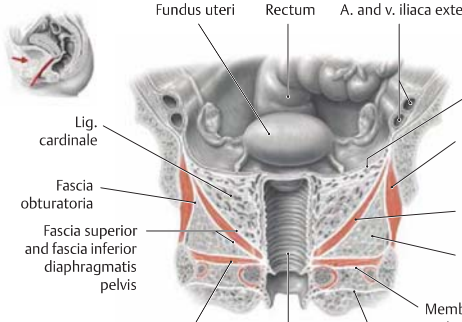
B Midsagittal section, viewed from the right side.

Peritoneal Relationships

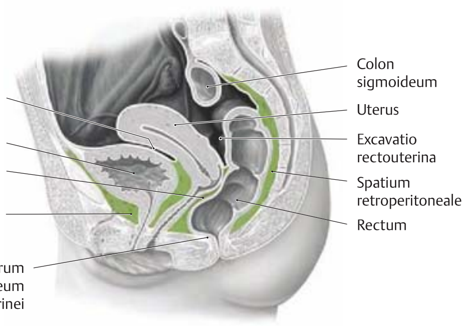
Fig. 12.12 Peritoneal relationships in the pelvis: Female



A Pelvis minor, anterosuperior view. *Retracted:* Intestinum tenue loops and colon (portions).

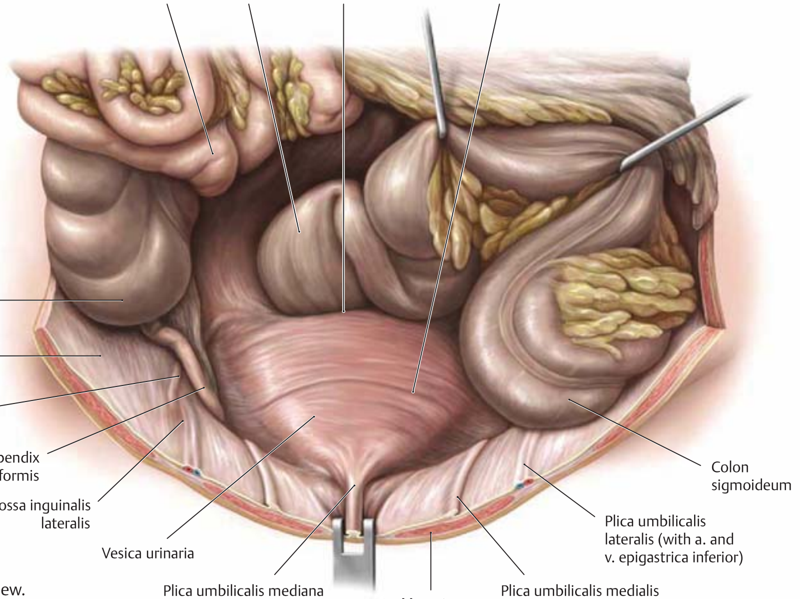


B Muscles of the pelvic floor. Coronal section, anterior view.

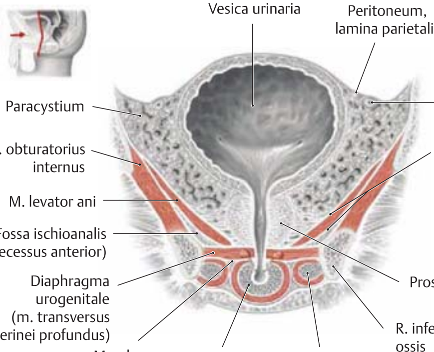


C Visceral fasciae. Midsagittal section, viewed from the left side.

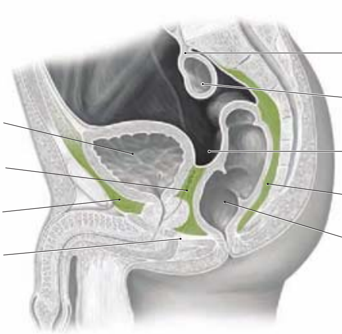
Fig. 12.13 Peritoneal relationships in the pelvis: Male



A Lesser pelvis, anterosuperior view. *Retracted:* Intetstinum tenue loops and colon (portions).



B Muscles of the pelvic floor. Coronal section, anterior view.



C Visceral fasciae. Midsagittal section, viewed from the left side.

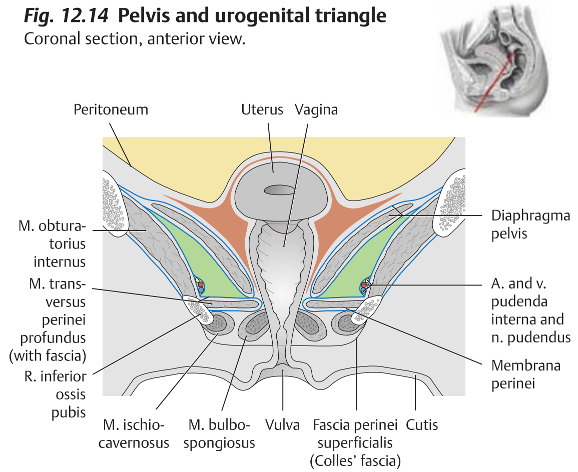
Pelvis & Perineum

Table 12.5 Divisions of the pelvis and perineum

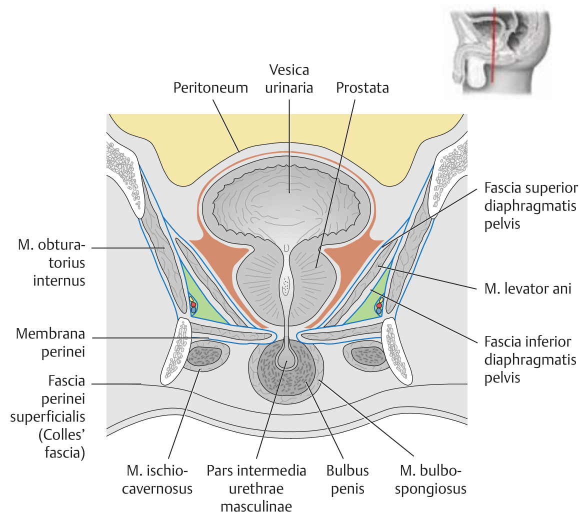
The levels of the pelvis are determined by bony landmarks (crista iliaca and aperatura pelvis superior, see p. 126). The contents of the perineum are separated by the diaphragma pelvis and two fascial layers.

Region	Subdivision	Contents
Crista iliaca		
Pelvis	**Pelvis major**	• Ileum (coils)
		• Caecum and appendix
		• Colon sigmoideum
		• A./v. iliaca communis and externa
		• Plexus lumbalis
	Aperatura pelvis superior	
	Pelvis minor	• Ureter distalis
		• Vesica urinaria
		• Rectum
		♀: Vagina, uterus, tuba uterina, and ovarium
		♂: Ductus deferens, glandula vesiculosa, and prostata
		• A./v. iliaca interna. and branches
		• Plexus sacralis
		• Plexus hypogastricus inferior
Diaphragma pelvis (m. levator ani with fascia diaphragmatica pelvis superior and inferior)		
Perineum	**Spatium perinei profundum**	• M. sphincter urethrae and m. transversus perinei profundus
		• Urethra (pars membranacea)
		• Vagina
		• Rectum
		• Glandula bulbourethralis
		• Fossa ischioanalis
		• A./v. pudenda interna, n. pudendus and branches
	Membrana perinei	
	Spatium perinei superficiale	• M. ischiocavernosus, m. bulbocavernosus, and m. transversus perinei superficialis
		• Urethra (pars spongiosa)
		• Clitoris and penis
		• A./v. pudenda interna, n. pudendus and branches
	Fascia perinealis (Colles') superficialis	
	Spatium (perineale) subcutaneum	• Fat
Cutis		

Fig. 12.14 **Pelvis and urogenital triangle**
Coronal section, anterior view.



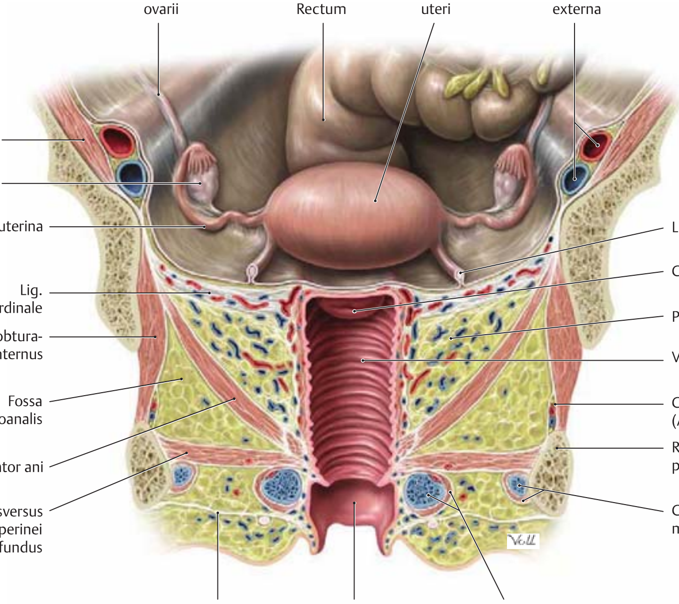
A Female.



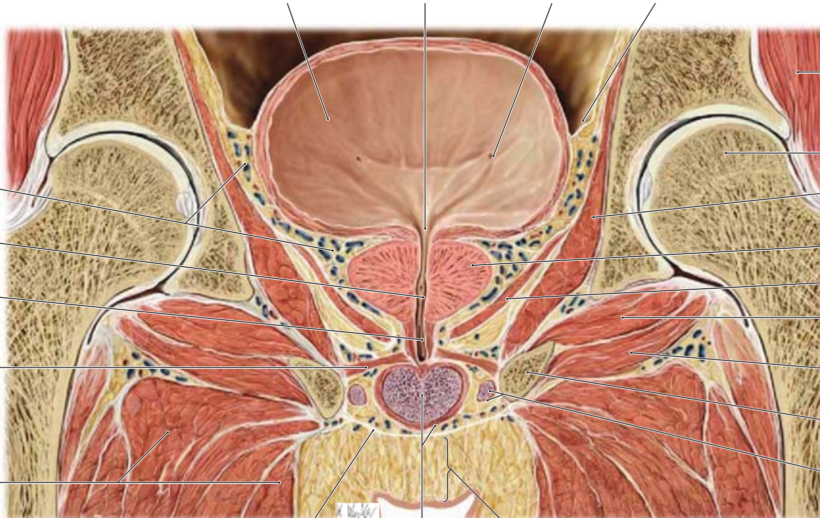
B Male.

- Cavitas peritonealis
- Subperitoneal space
- Fossa ischioanalis
- Fascia pelvis visceralis
- Fascia pelvis parietalis

Fig. 12.15 Pelvis: Coronal section
Anterior view.



A Female.



B Male.

Fig. 12.16 **Abdomen: Transverse section**
Inferior view.

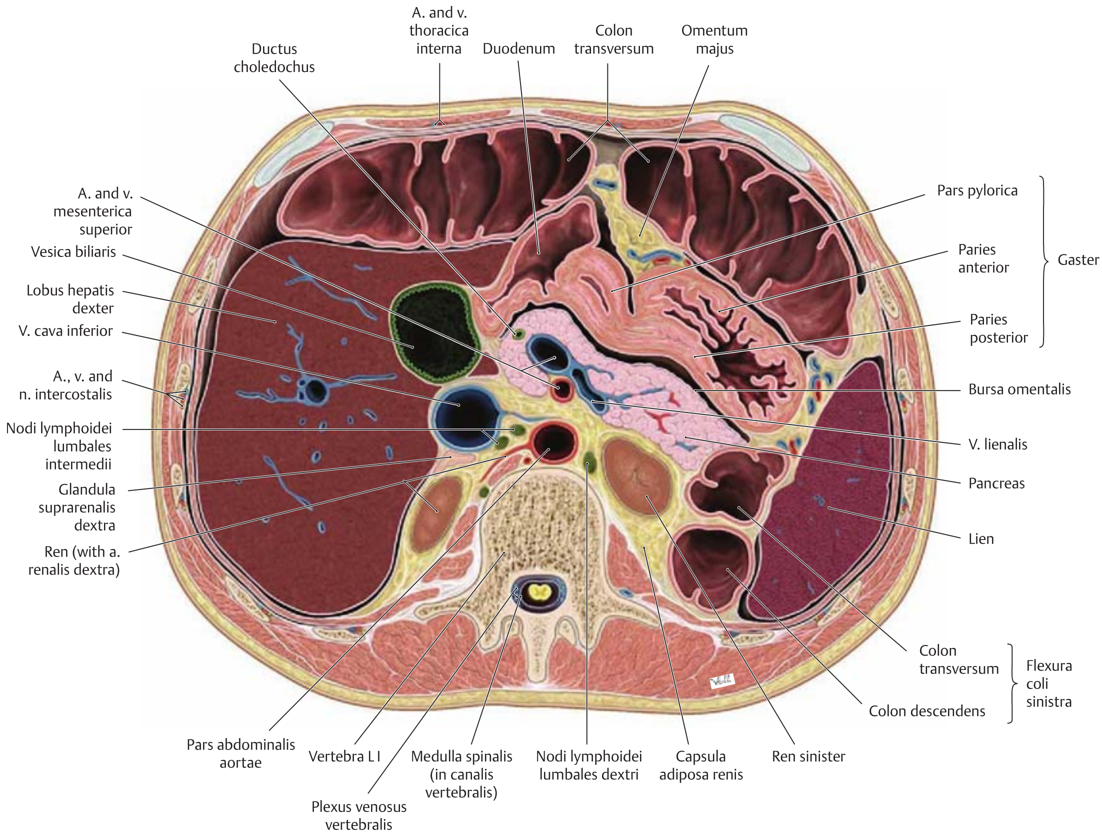
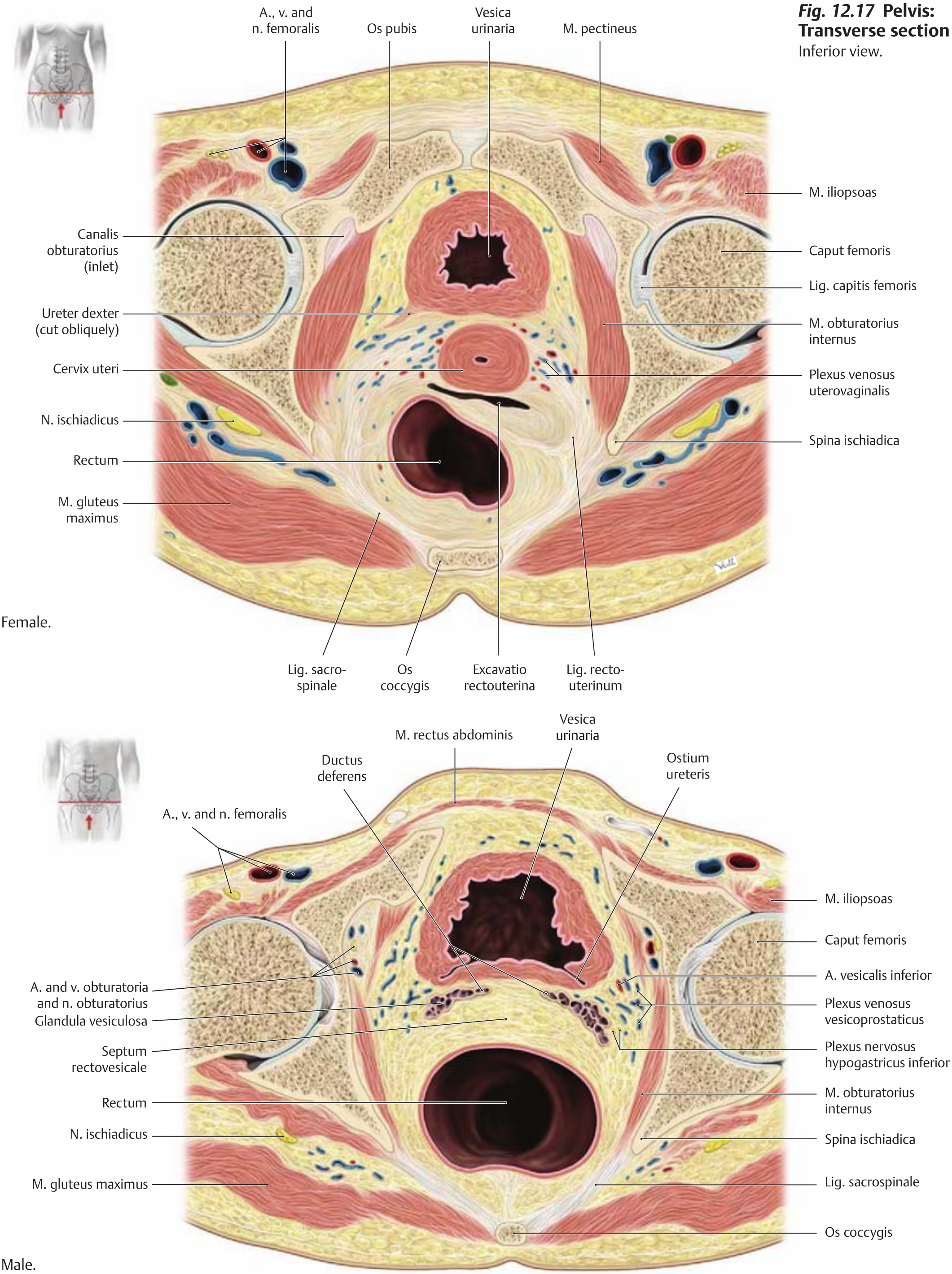


Fig. 12.17 Pelvis: Transverse section
Inferior view.

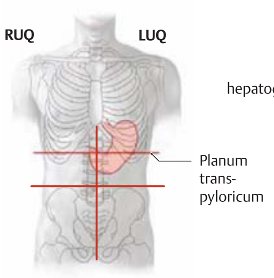


A Female.

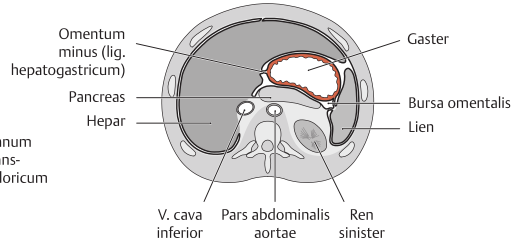
B Male.

Gaster

Fig. 13.1 Gaster: Location

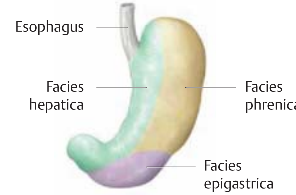


A Anterior view.

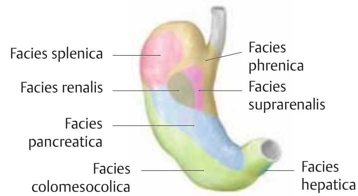


B Transverse section, inferior view.

Fig. 13.2 Surfaces of gaster



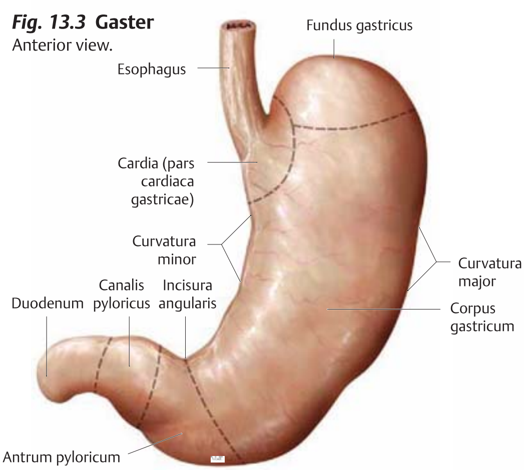
A Anterior view.



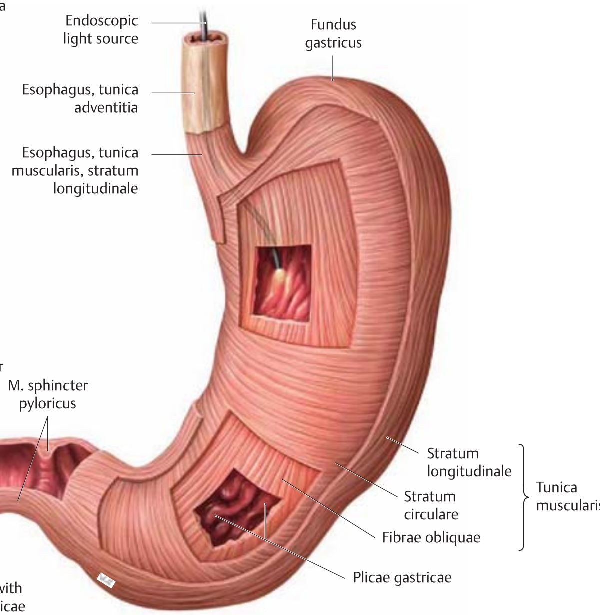
B Posterior view.

Fig. 13.3 Gaster

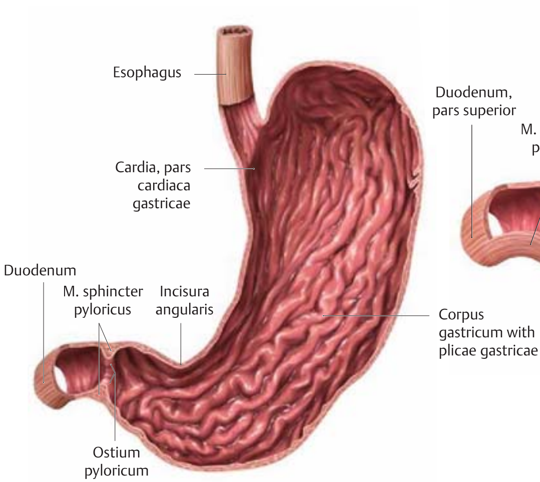
Anterior view.



A Anterior wall.



B Muscular layers. *Removed:* Serosa and sub-serosa. *Windowed:* Muscular coat.



C Interior. *Removed:* Anterior wall.

Gaster is found in the right and left upper quadrants. It is intraperitoneal, its mesenterium being omentum minus and omentum majus.

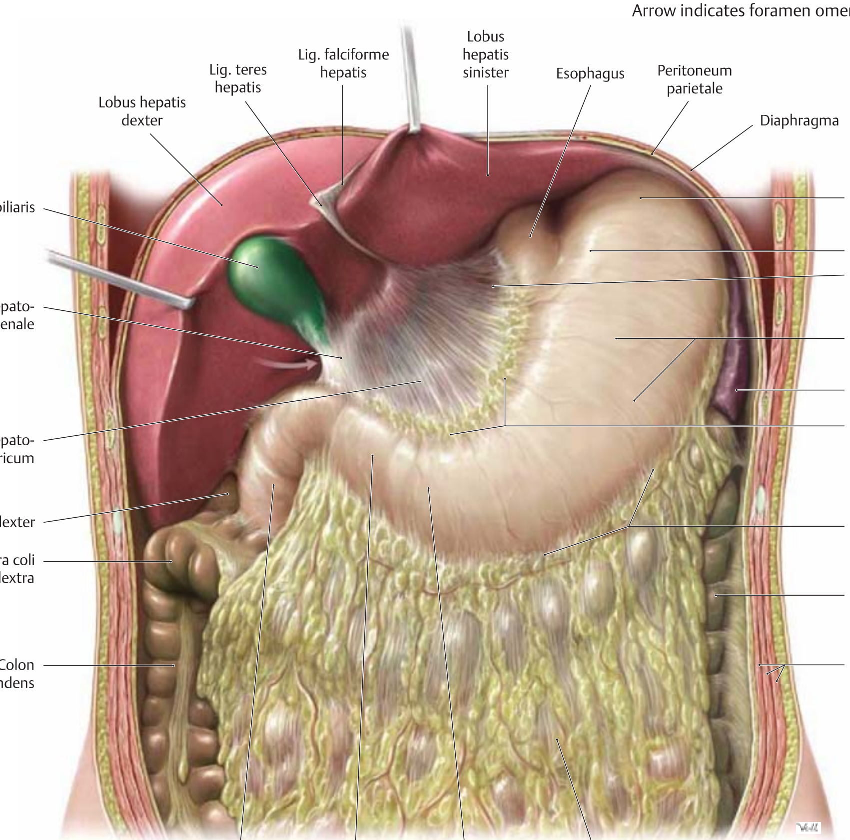
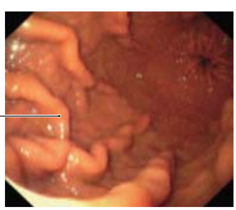


Fig. 13.4 **Gaster in situ**
Anterior view of the opened upper abdomen. Arrow indicates foramen omentale.

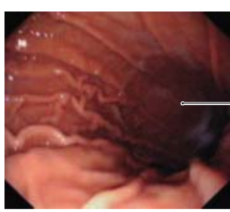
Clinical

Gastritis and ulcus ventriculi

Gastritis and ulcus ventriculi, the two most common diseases of the stomach, are associated with increased acid production and are caused by alcohol, drugs such as aspirin, and the bacterium*Helicobacter pylori*. Symptoms include lessened appetite, pain, and even bleeding, which manifests as black stool or dark brown material in vomit. Gastritis is limited to the inner surface of the stomach, while ulcus ventriculi extend into the stomach wall. The ulcus ventriculi in **C** is covered with fibrin and shows hematin spots.



A Body of normal gaster.



B Normal antrum pyloricum.

C Ulcus ventriculi.

Duodenum

Intestinum tenue consists of the duodenum, jejunum, and ileum (see p. 162). The duodenum is primarily retroperitoneal and divided into four parts: superior, descending, horizontal, and ascending.

Fig. 13.5 **Duodenum: Location**
Anterior view.

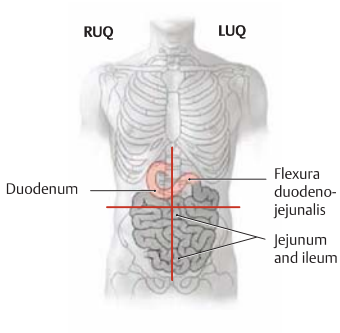


Fig. 13.6 **Parts of the duodenum**
Anterior view.

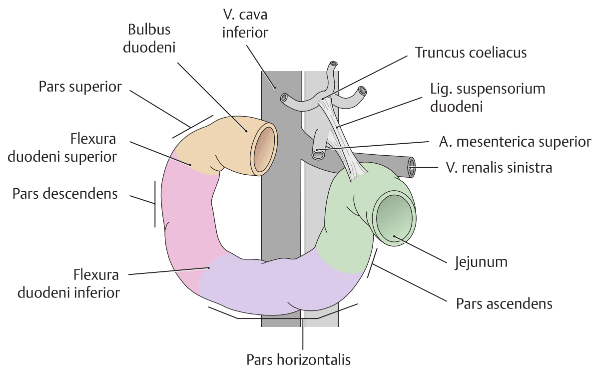


Fig. 13.7 **Duodenum**
Anterior view with the anterior wall opened.

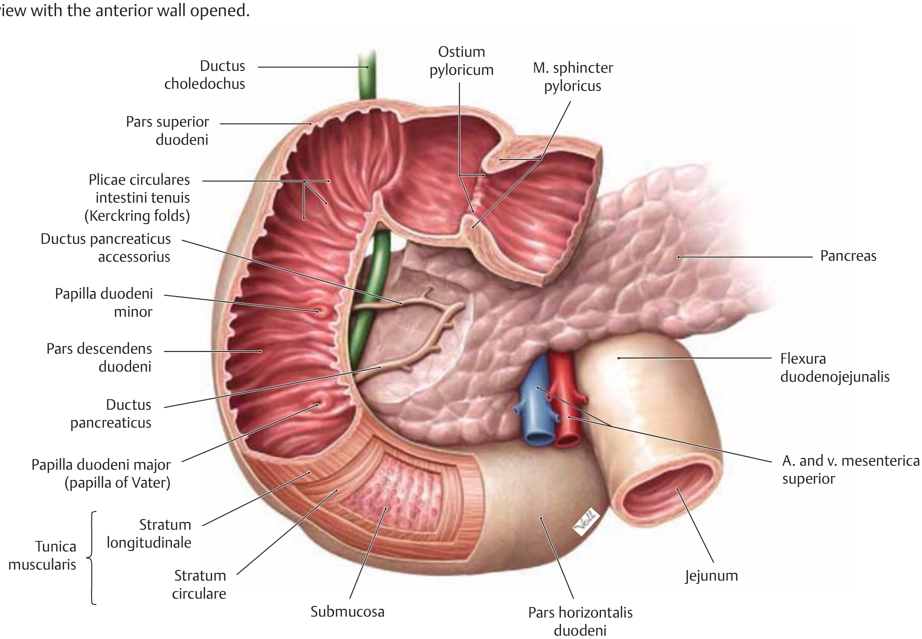
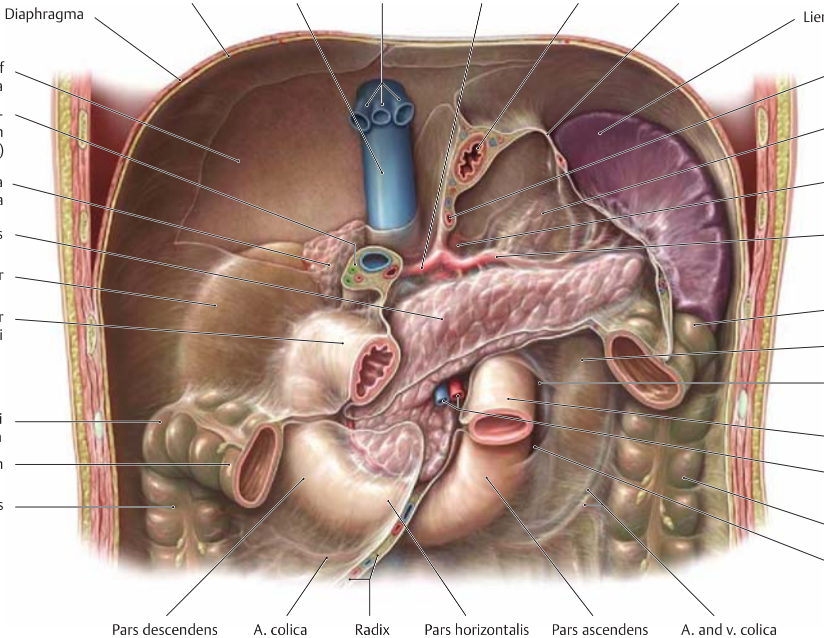


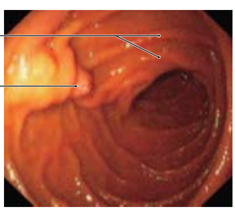
Fig. 13.8 **Duodenum in situ**
Anterior view. *Removed:* Gaster, hepar, intestinum tenue, and large portions of colon transversum. *Thinned:* Retroperitoneal fat and connective tissue.



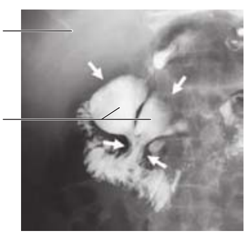
Clinical

Endoscopy of the papillary region

Two important ducts end in the papillary region of the duodenum: ductus choledocus and the ductus pancreaticus (see Fig. 13.7). These ducts may be examined by X-ray through endoscopic retrograde cholangiopancreatography (ERCP), in which dye is injected endoscopically into papilla duodeni major. Duodenal diverticula (generally harmless outpouchings) may complicate the procedure.



A Endoscopic appearance.



B Radiograph.

Jejunum & Ileum

Fig. 13.9 Jejunum and ileum: Location
Anterior view. The intraperitoneal jejunum and ileum are enclosed by the mesentery proper.

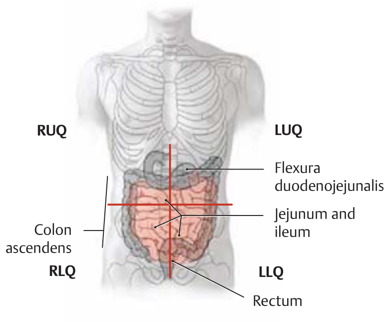
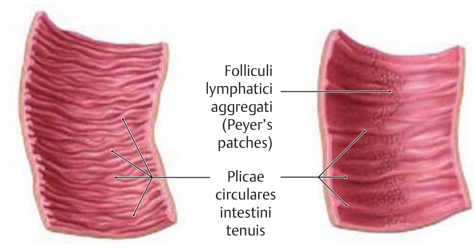
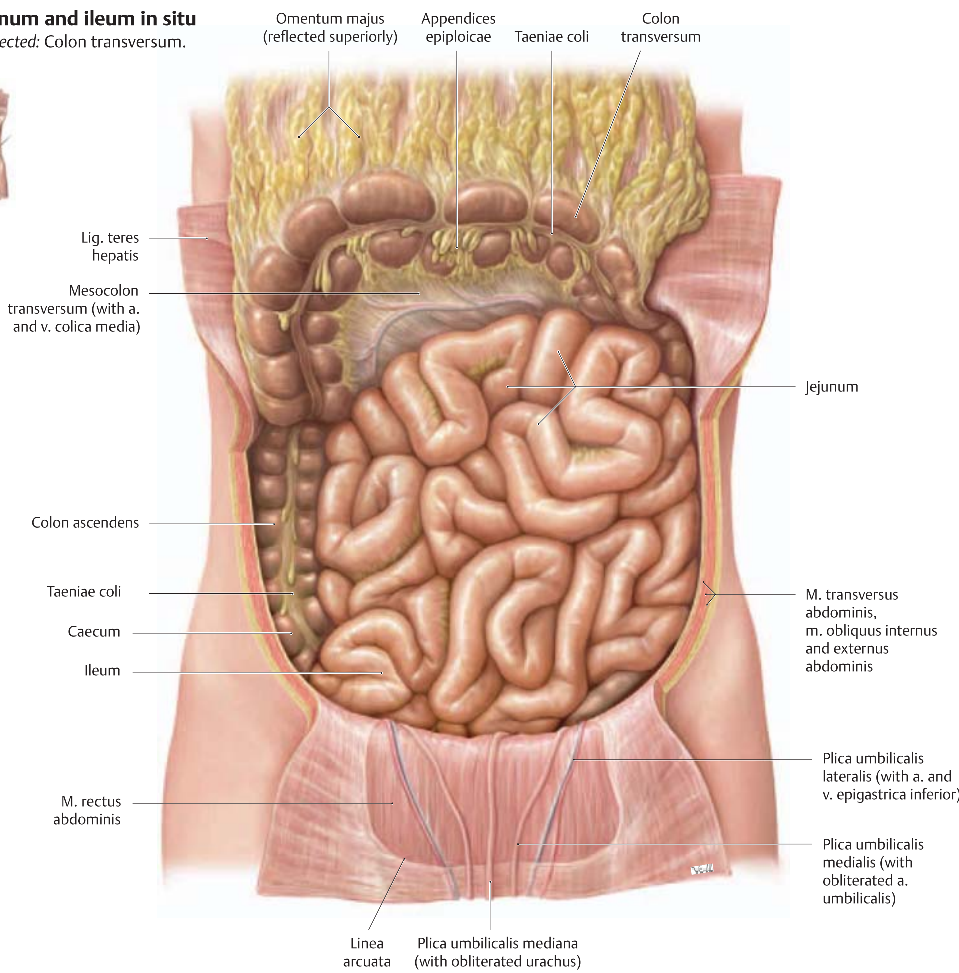


Fig. 13.10 Wall structure of intestinum tenue
Macroscopic views of the longitudinally opened small intestine.



A Jejunum. **B** Ileum.

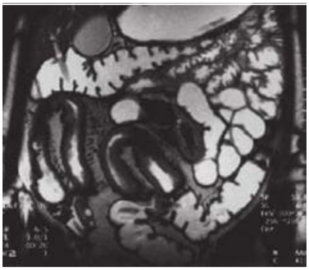
Fig. 13.11 Jejunum and ileum in situ
Anterior view. *Reflected:* Colon transversum.



Clinical

Morbus Crohn

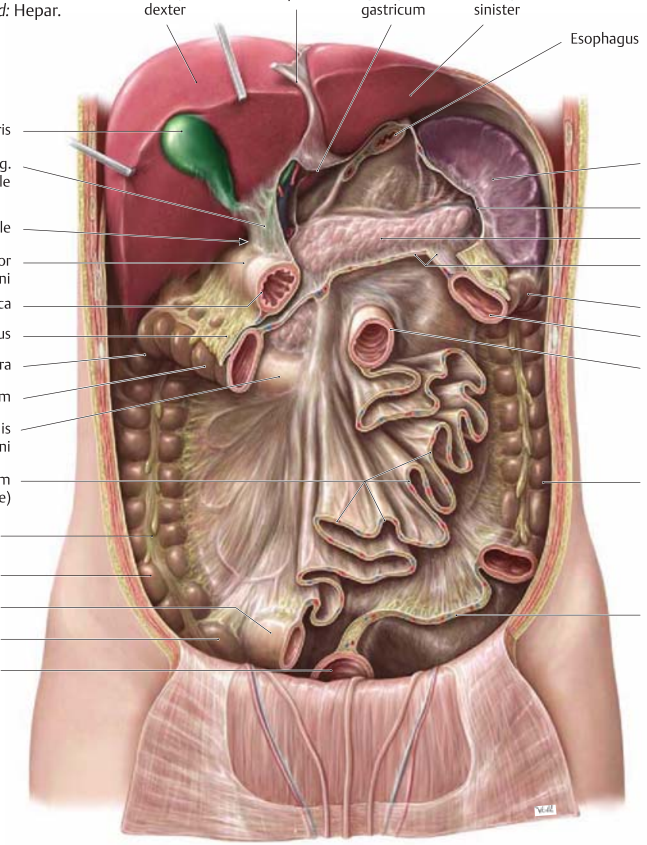
Mb. Crohn, a chronic inflammation of the digestive tract, occurs most often in the terminal ileum (30% of cases). Patients are generally young and suffer from abdominal pain, nausea, elevated body temperature, and diarrhea. Initially, these symptoms can be confused with appendicitis. Complications of Crohn's disease often include anal fistulae (**B**).



A MRI showing thickened wall of terminal ileum.

B Double-contrast radiograph. Arrow indicates fistula.

Fig. 13.12 **Mesenterium of intestinum tenue**
Anterior view. *Removed:* Gaster, jejunum, and ileum. *Reflected:* Hepar.



Cecum, Appendix & Colon

Intestinum crassum consists of the cecum, appendix, colon, and rectum (see p. 166). The colon is divided into four parts: ascendens, transversum, descendens, and sigmoideum. The appendix, colon transversum, and colon sigmoideum are intraperitoneal (suspended by the mesoappendix, mesocolon transversum, and mesocolon sigmoideum, respectively).

Fig. 13.13 Intestinum crassum: Location
Anterior view.

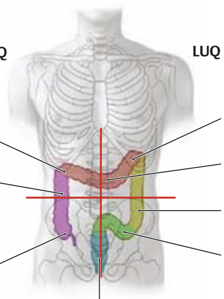


Fig. 13.14 Ostium ileale
Anterior view of longitudinal coronal section.

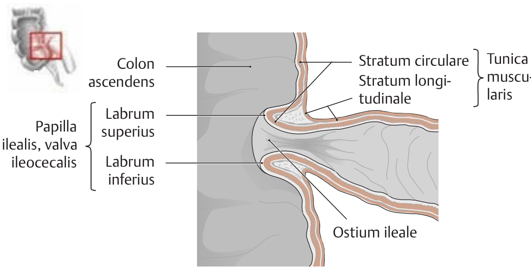


Fig. 13.15 Intestinum crassum
Anterior view.

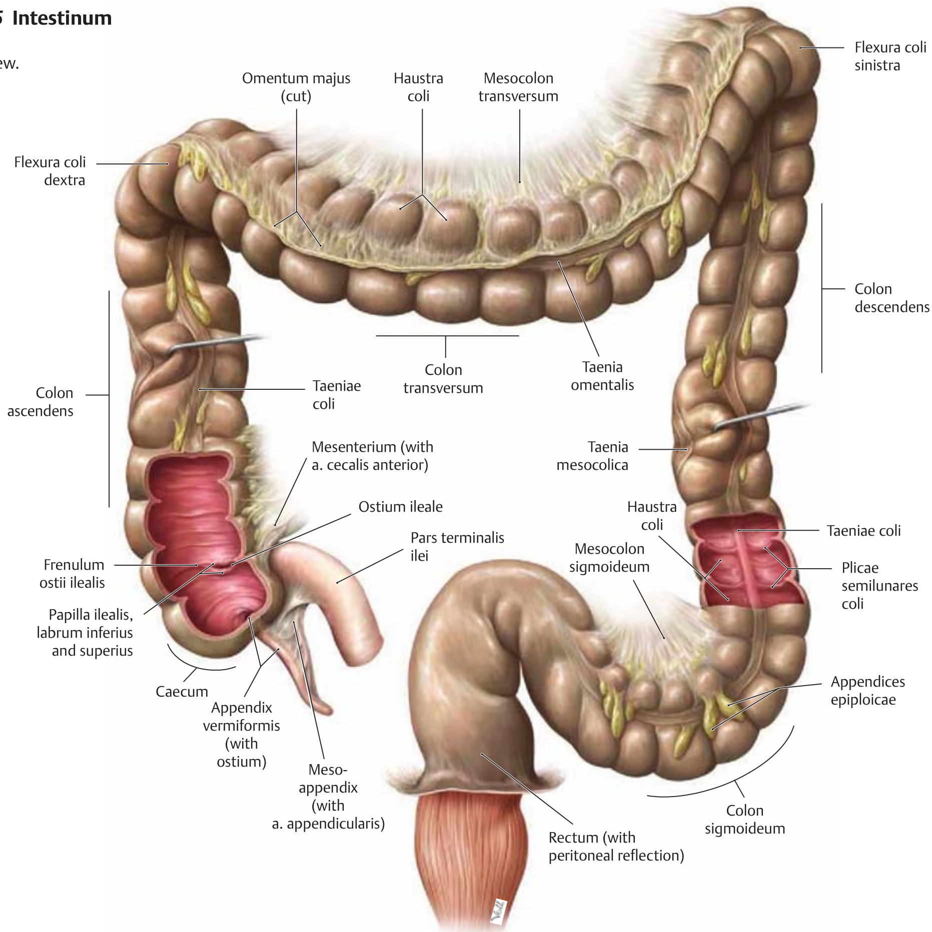
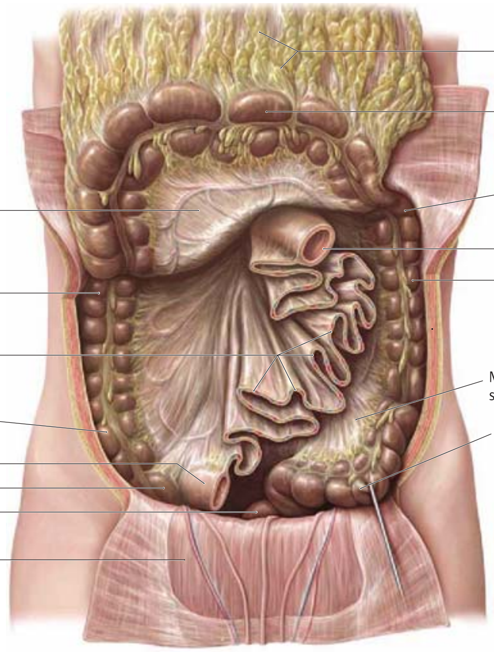


Fig. 13.16 Intestinum crassum in situ



A Anterior view. *Reflected:* Colon transversum and omentum majus. *Removed:* Intraperitoneal intestinum tenue.

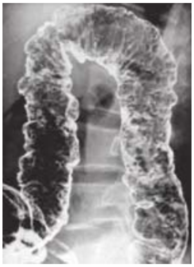
B Normal radiographic appearance. Double-contrast radiograph, anterior view.

Clinical

Colitis

Ulcerative colitis is a chronic inflammation of the large intestine, often starting in the rectum. Typical symptoms include diarrhea (sometimes with blood), pain, weight loss, and inflammation of other organs. Patients are also at higher risk for colorectal carcinomas.

A Colonoscopy of ulcerative colitis.



B Early-phase colitis. Residual normal mucosa appears as pseudopolyps.

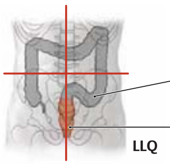
Colon carcinoma

Malignant tumors of the colon and rectum are among the most frequent solid tumors. More than 90% occur in patients over the age of 50. In early stages, the tumor may be asymptomatic; later symptoms include loss of appetite, changes in bowel movements, and weight loss. Blood in the stools is particularly incriminating, necessitating a thorough examination. Hemorrhoids are not a sufficient explanation for blood in stools unless all other tests (including a colonoscopy) are negative.

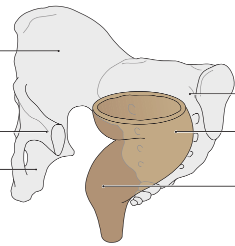
C Colonoscopy of colon carcinoma. The tumor partially blocks the lumen of the colon.

Rectum & Canalis Analis

Fig. 13.17 Rectum: Location



A Anterior view.



B Left anterolateral view.

Fig. 13.18 Closure of the rectum

Left lateral view. M. puborectalis acts as a muscular sling that kinks the anorectal junction. It functions in the maintenance of fecal continence.

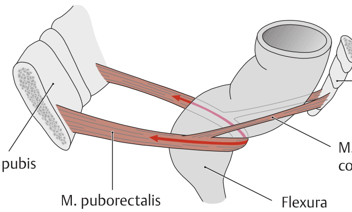


Fig. 13.19 Rectum in situ

Coronal section, anterior view of the female pelvis. The upper third of the rectum is covered with peritoneum viscerale on its anterior and lateral sides. The middle third is covered only anteriorly and the lower third is inferior to the peritoneum parietale.

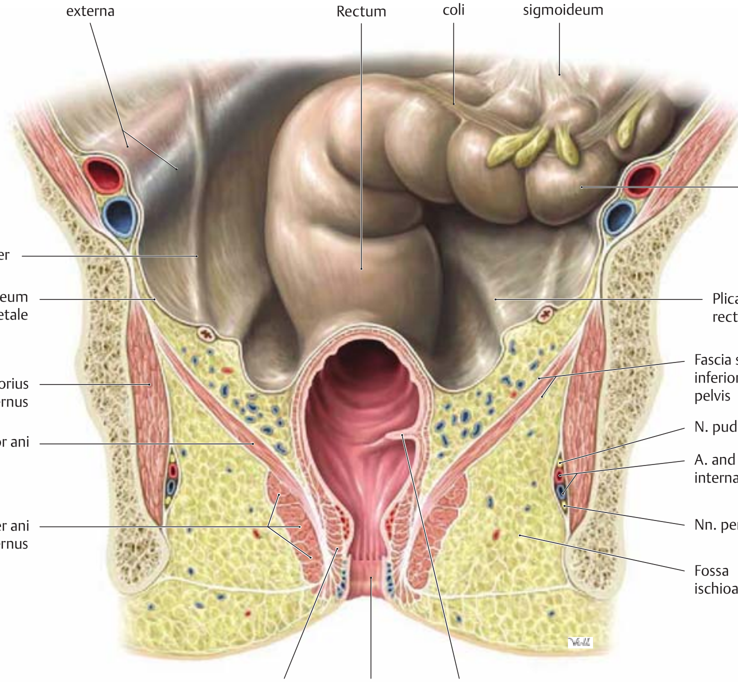
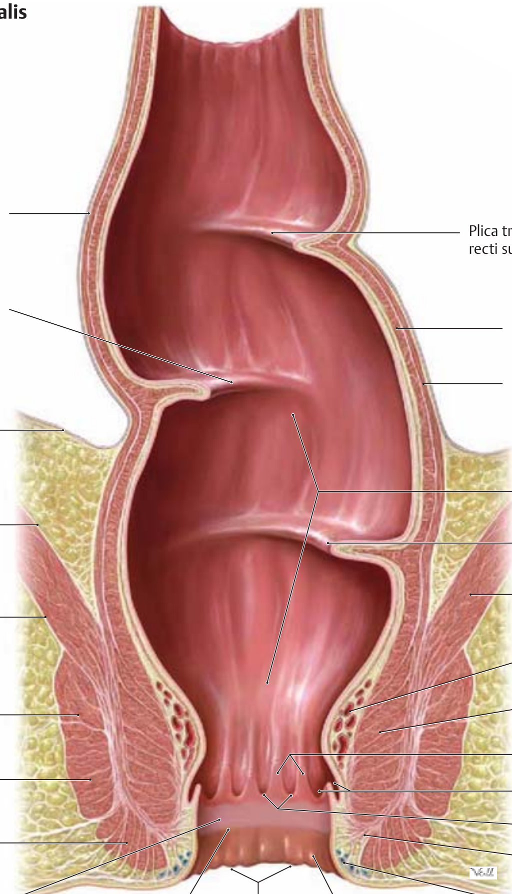


Fig. 13.20 **Rectum and canalis analis**
Coronal section, anterior view with the anterior wall removed.



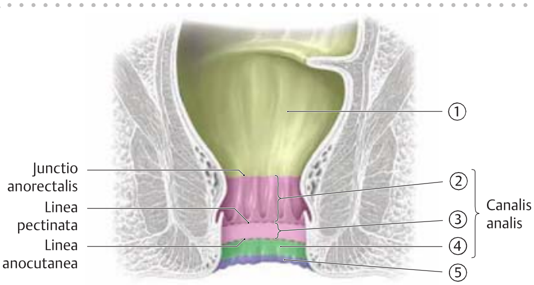
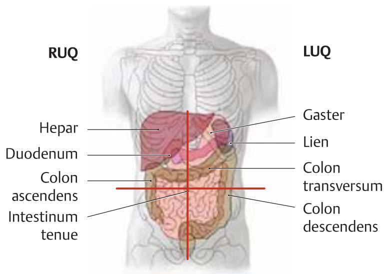


Table 13.1 Regions of the rectum and anal canal

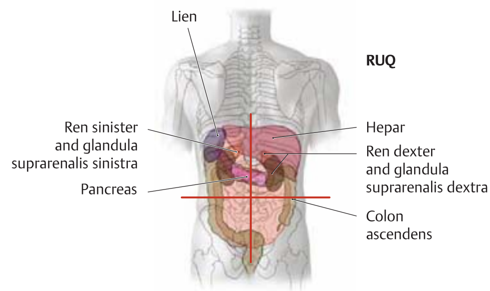
Region		Epithelium
① Rectum		Colon-like with crypts; simple columnar with goblet cells
Canalis analis	② Zona columnalis	Stratified, nonkeratinized squamous
	③ Pecten analis	
	④ Zona cutanea	Stratified, keratinized squamous with glandulae sebaceae
⑤ Perianal skin (pigmented)		Stratified, keratinized squamous with glandulae sebaceae, hairs, and glandulae sudoriferae

Hepar: Overview

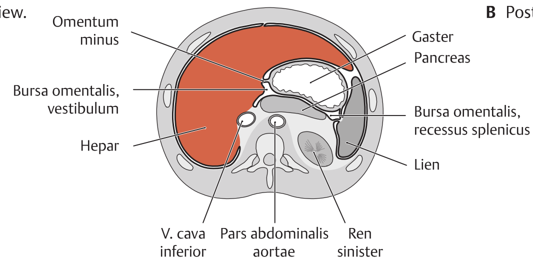
Fig. 13.21 **Hepar: Location**



A Anterior view.



B Posterior view.



C Transverse section, inferior view.

Fig. 13.22 **Hepar in situ**

Anterior view with hepar retracted. *Removed:* Gaster, jejunum, and ileum. Hepar is intraperitoneal except for its “bare area” (see Fig. 13.26); its mestenterium include ligg. falciforme, coronarium, and triangulare (see Fig. 13.27).

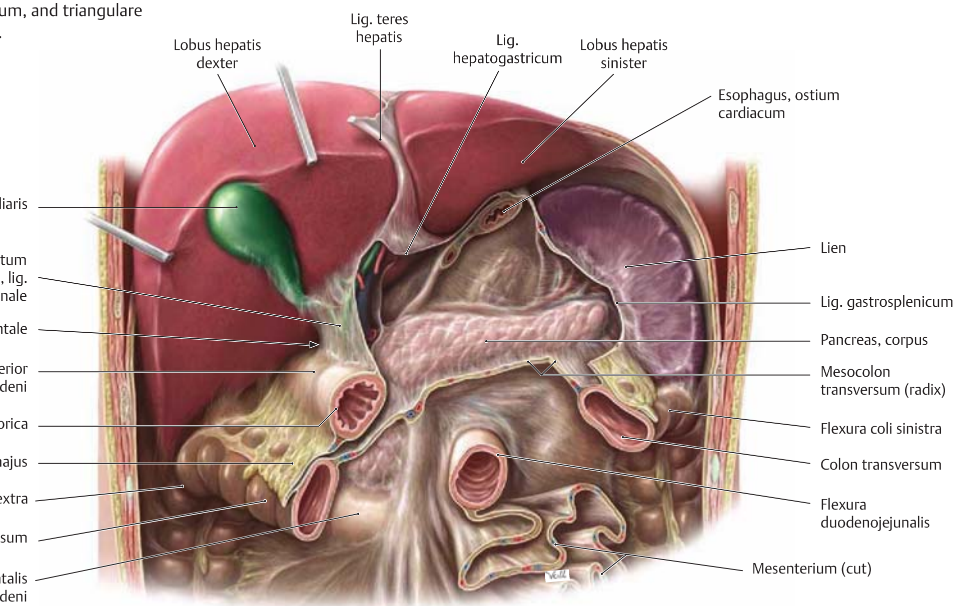
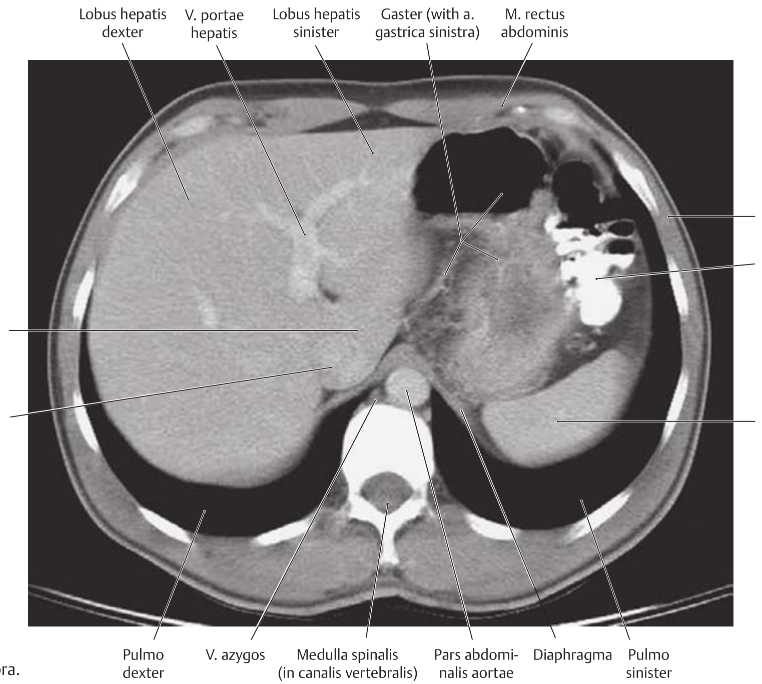
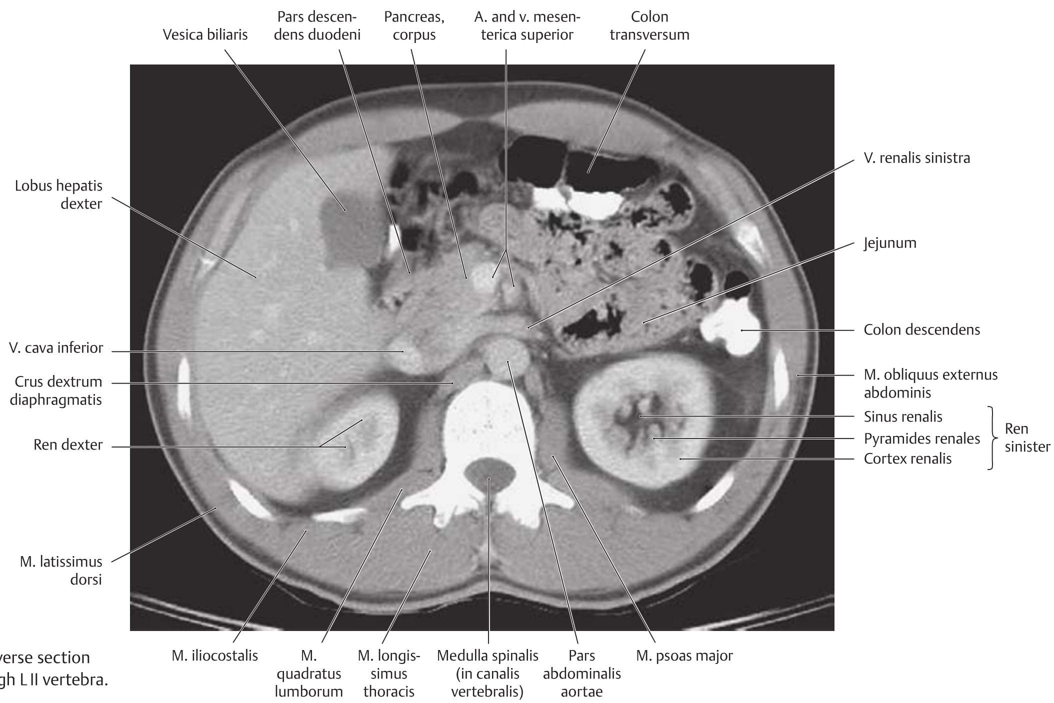


Fig. 13.23 **Abdominal MRI**
Inferior view.



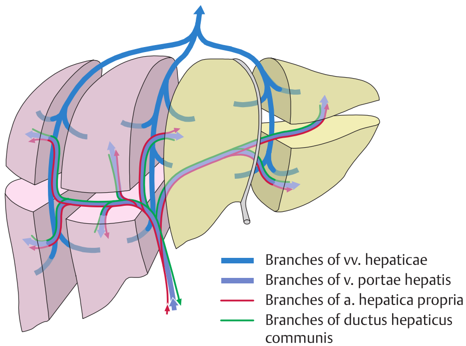
A Transverse section through T XII vertebra.

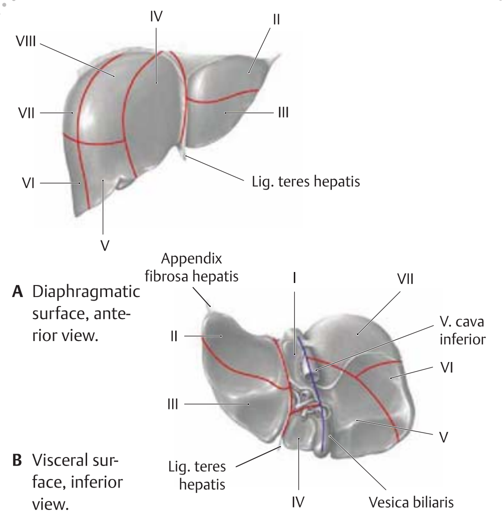


B Transverse section through L II vertebra.

Hepar: Segments & Lobes

***Fig. 13.24* Segmentation of hepar**
Anterior view. The components of the portal triad (a. hepatica propria, v. portae hepatis, and ductus hepaticus communis, see pp. 172, 219) divides the liver into hepatic segments (see Table 13.2).





A Diaphragmatic surface, anterior view.

B Visceral surface, inferior view.

Table 13.2	**Hepatic segments**		
Part	**Division**	**Segmentum**	
Pars hepatis sinistra	Pars posterior	I	Lobus caudatus
	Divisio lateralis sinistra	II	Posterius laterale sinistrum
		III	Anterius laterale sinistrum
	Divisio medialis sinistra	IV	Mediale sinistrum
Pars hepatis dextra	Divisio medialis dextra	V	Anterius mediale dextrum
		VIII	Posterius mediale dextrum
	Divisio lateralis dextra	VII	Posterius laterale dextrum
		VI	Anterius laterale dextrum

***Fig. 13.25* Hepar: Areas of organ contact**
Visceral surface, inferior view.

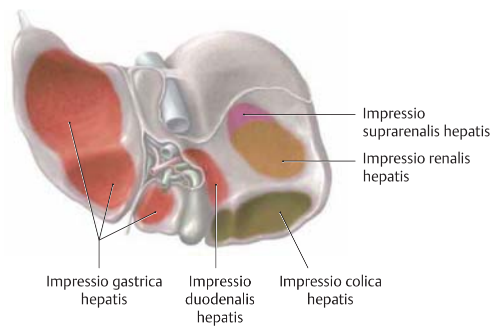
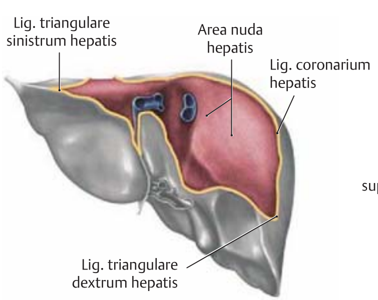
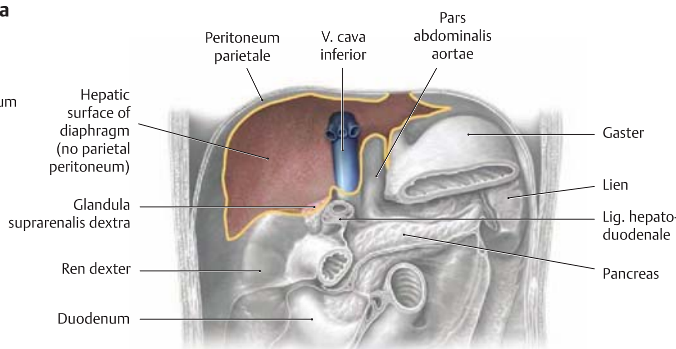


***Fig. 13.26* Attachment of hepar to diaphragma**

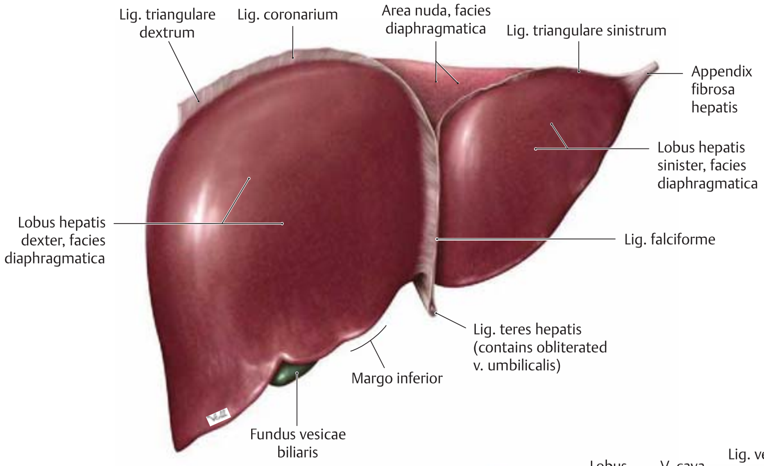


A Diaphragmatic surface of the liver, posterior view.

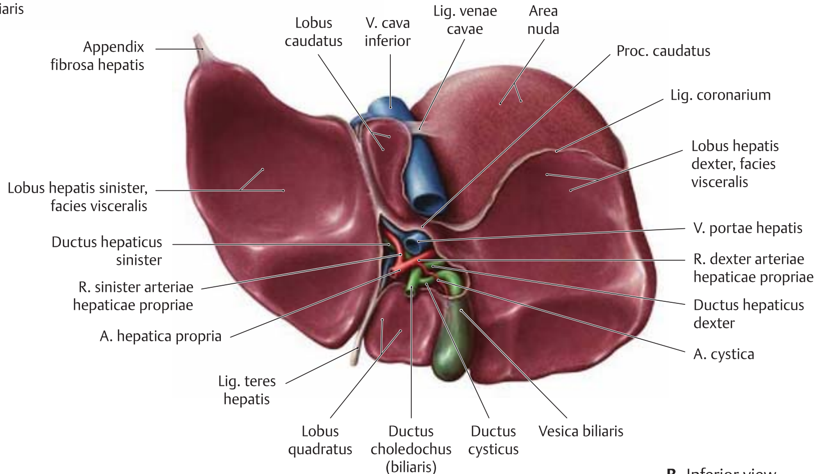


B Hepatic surface of the diaphragm, anterior view.

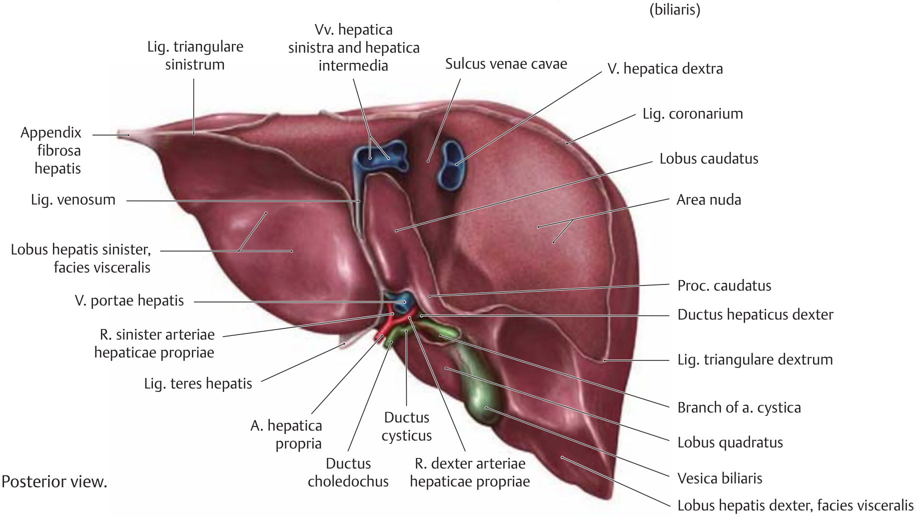
Fig. 13.27 **Surfaces hepar**
The liver is divided by its ligaments into four lobes: lobus hepatis dexter and sinister, lobus candatus and lobus quadratus.



A Anterior view.



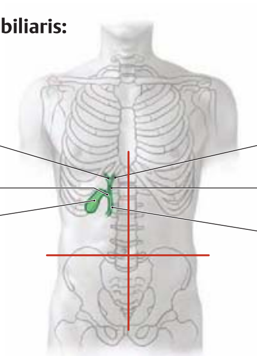
B Inferior view.



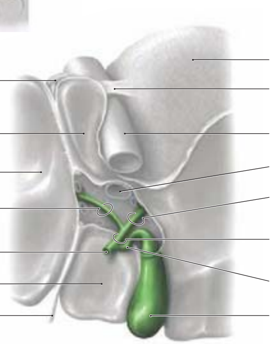
C Posterior view.

Vesica Biliaris & Bile Ducts

Fig. 13.28 **Vesica biliaris: Location**



A Anterior view.



B Inferior view.

Fig. 13.29 **Hepatic bile ducts: Location**

Projection onto surface of hepar, anterior view.

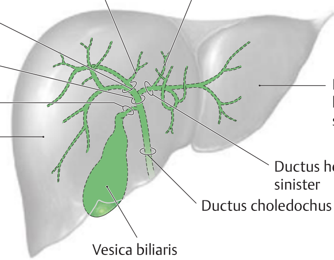
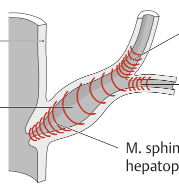
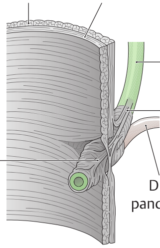


Fig. 13.30 **Biliary sphincter system**



A Sphincters of the pancreatic and bile ducts.



B Sphincter system in the duodenal wall.

Fig. 13.31 **Extrahepatic bile ducts**

Anterior view. *Opened:* vesica biliaris and duodenum.

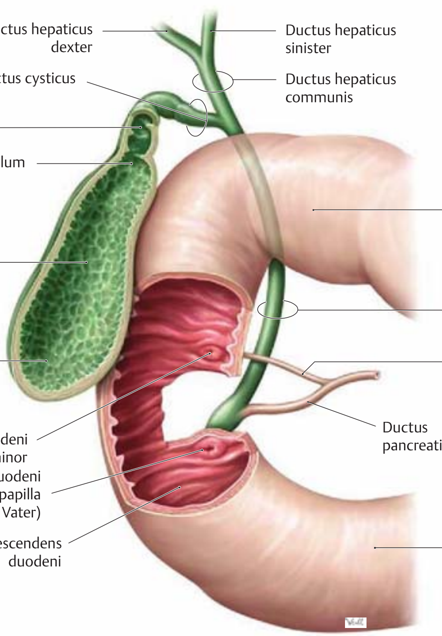
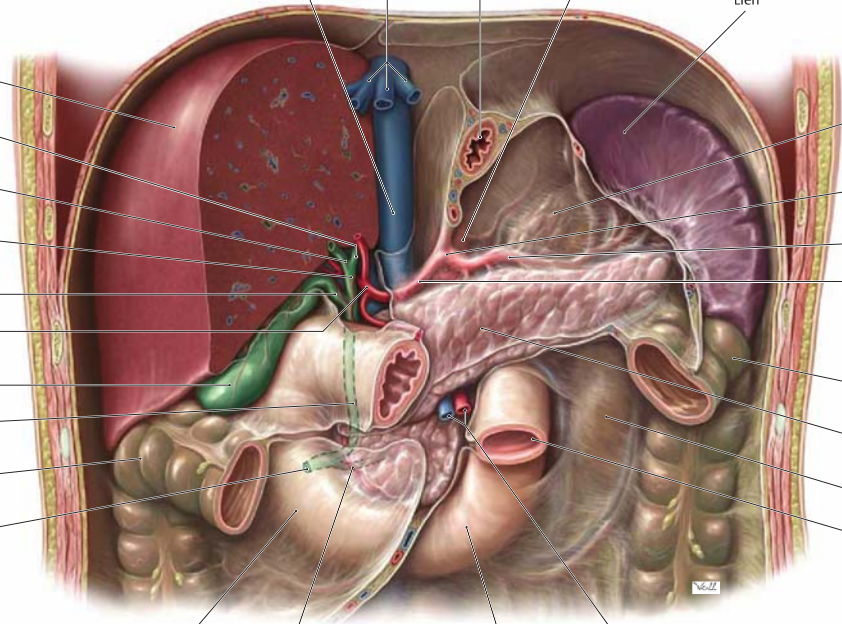
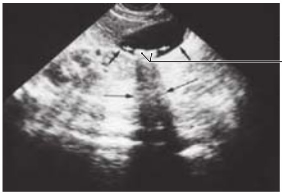


Fig. 13.32 **Biliary tract in situ**
Anterior view. *Removed:* Gaster, intestinum tenue, colon transversum, and large portions of hepar. The vesica biliaris is intraperitoneal, covered by peritoneum viscerale where it is not attached to hepar.



Clinical

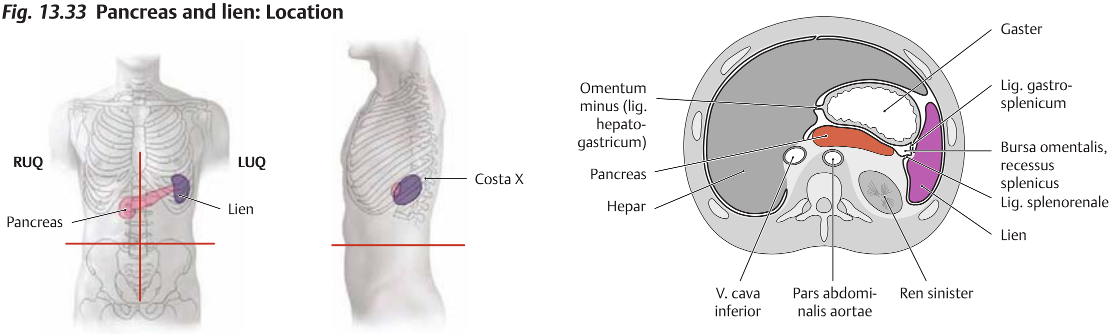
Obstruction of the ductus choledochus
As bile is stored and concentrated in vesica biliaris, certain substances, such as cholesterol, may crystallize, resulting in the formation of gallstones. Migration of gallstones into the ductus choledochus causes severe pain (colic). Gallstones may also block the ductus pancreaticus in the papillary regions, causing highly acute or even life-threatening pancreatitis.



Ultrasound appearance of two gallstones. Black arrows mark the echo-free area behind the stones.

Pancreas & Lien

Fig. 13.33 **Pancreas and lien: Location**



A Anterior view.

B Left lateral view.

C Transverse section, inferior view.

Fig. 13.34 **Pancreas**
Anterior view with dissection of the ductus pancreaticus.

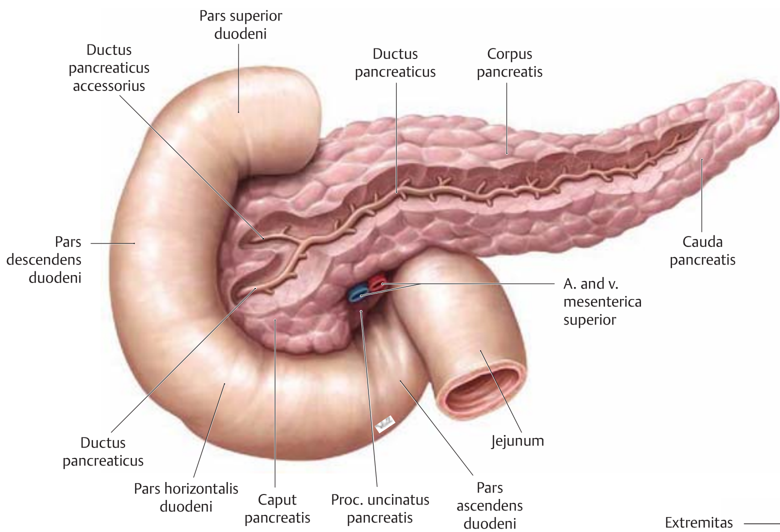
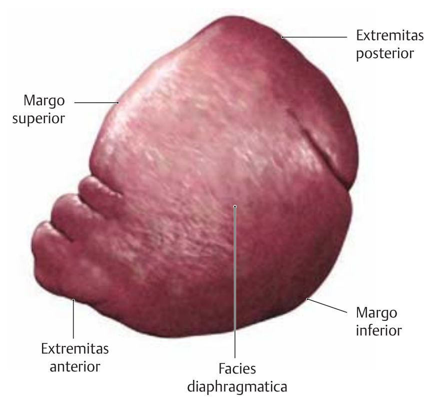
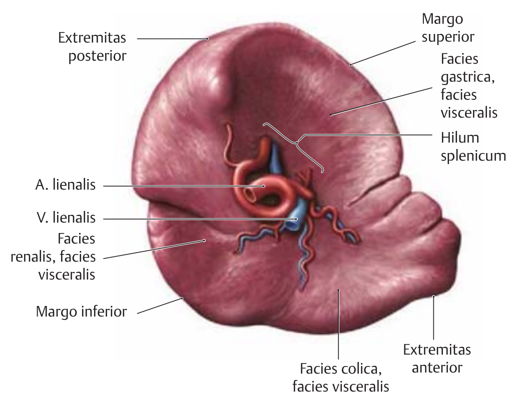


Fig. 13.35 **Lien**



A Costal surface.



B Visceral surface.

Fig. 13.36 Pancreas and lien in situ

Anterior view. *Removed:* Hepar, gaster, intestinum tenue, and intestinum crassum. The pancreas is retroperitoneal, while lien is intraperitoneal.

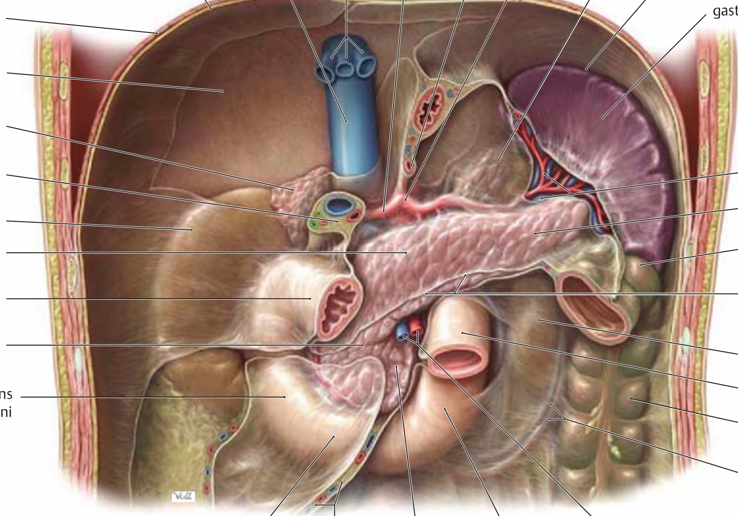
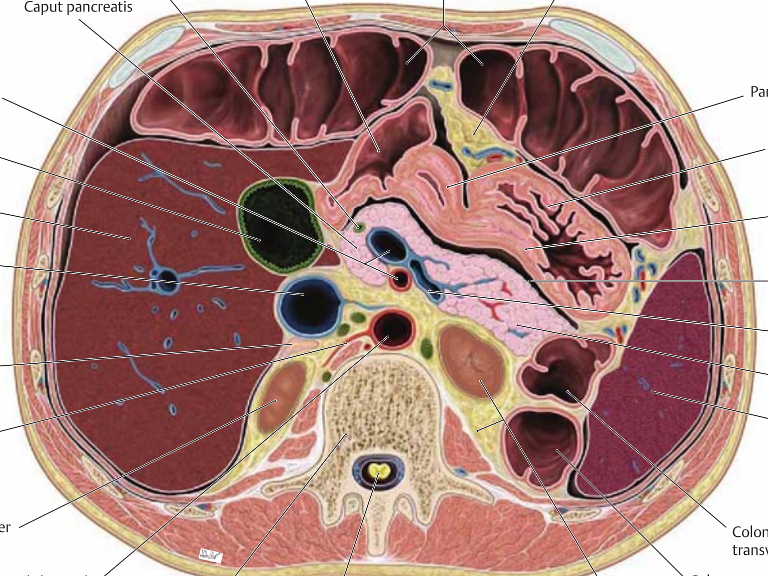


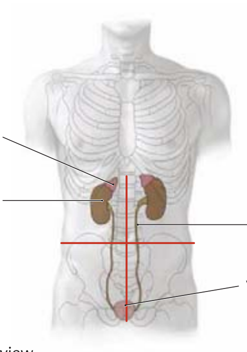
Fig. 13.37 Pancreas and lien: Transverse section

Inferior view. Section through L I vertebra.

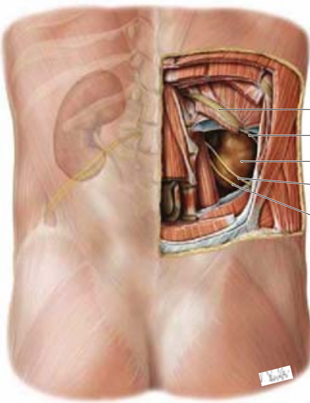


Renes & Glandulae Suprarenales: Overview

Fig. 13.38 **Renes gll. suprarenales: Location**



A Anterior view.



B Posterior view with the trunk wall opened.

Fig. 13.39 **Renes: Areas of organ contact**

Anterior view.

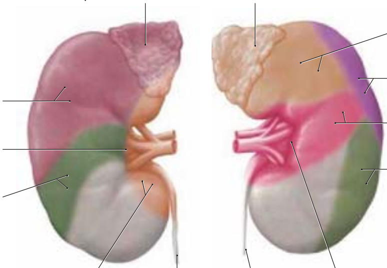


Fig. 13.40 **Ren dexter in the renal bed**

Sagittal section through the right renal bed.

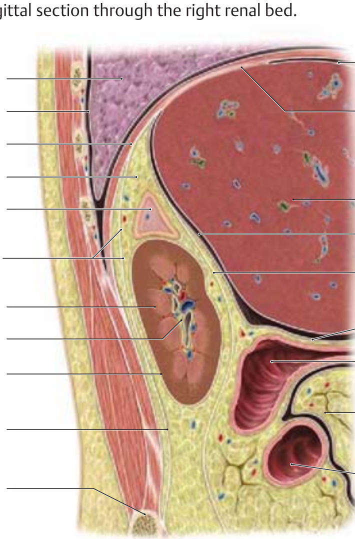
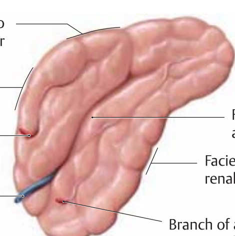
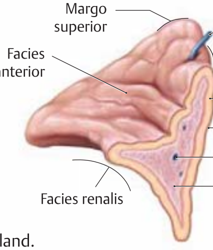


Fig. 13.41 **Glandula suprarenalis**

Anterior view.



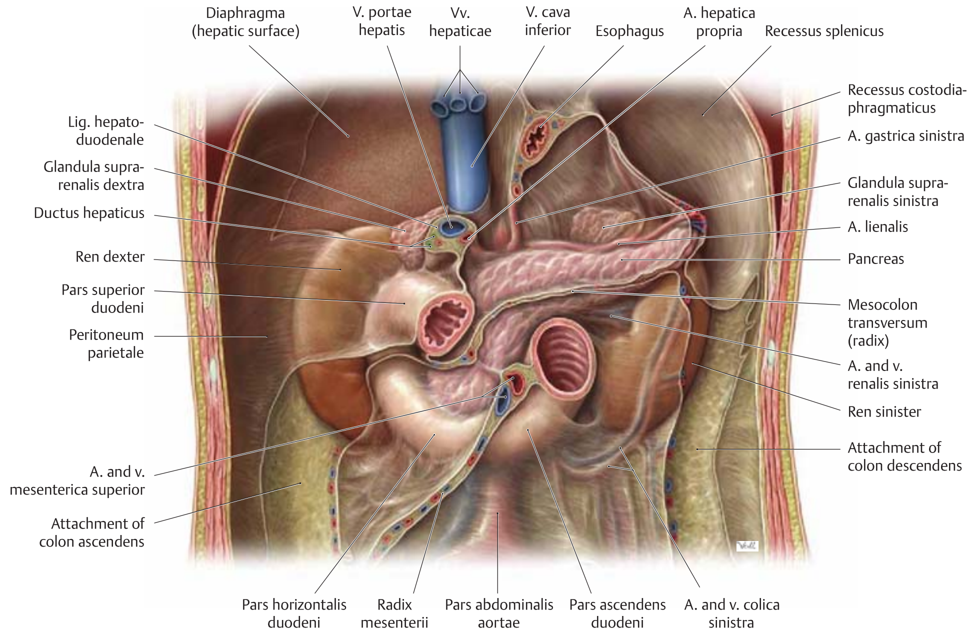
A Left gland.



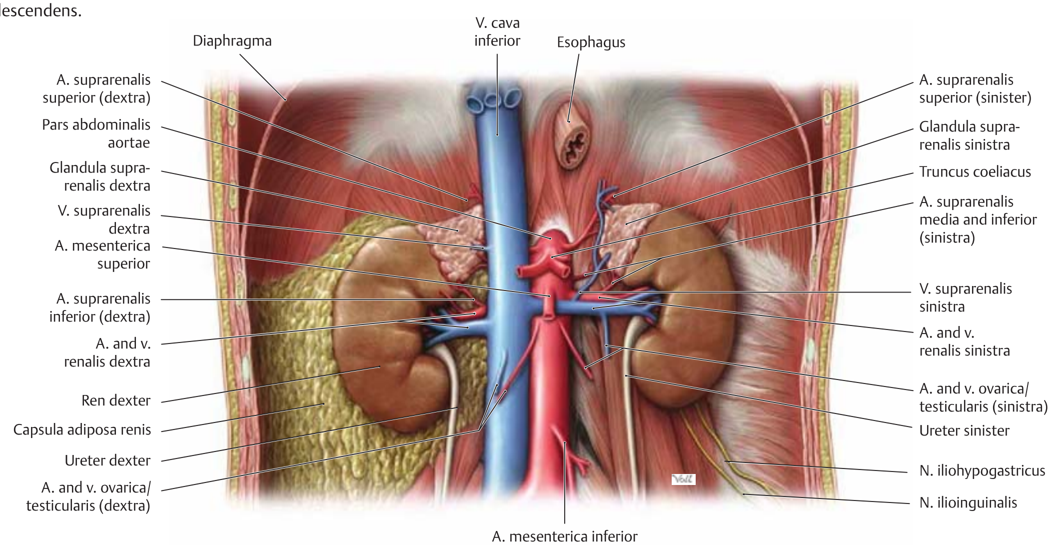
B Opened right gland.

Fig. 13.42 **Renes and gll. suprarenales in the retroperitoneum**

Anterior view. Both renes and gll. suprarenales are retroperitoneal.



A *Removed:* Intraperitoneal organs, along with portions of the colon ascendens and descendens.



B *Removed:* Peritoneum, lien, and gastrointestinal organs, along with fat capsule (left side). *Retracted:* Esophagus.

Renes & Glandulae Suprarenales: Features

Fig. 13.43 **Ren dexter and gl. suprarenalis**
Anterior view. *Removed:* Capsula adiposa renis.
Retracted: V. cava inferior.

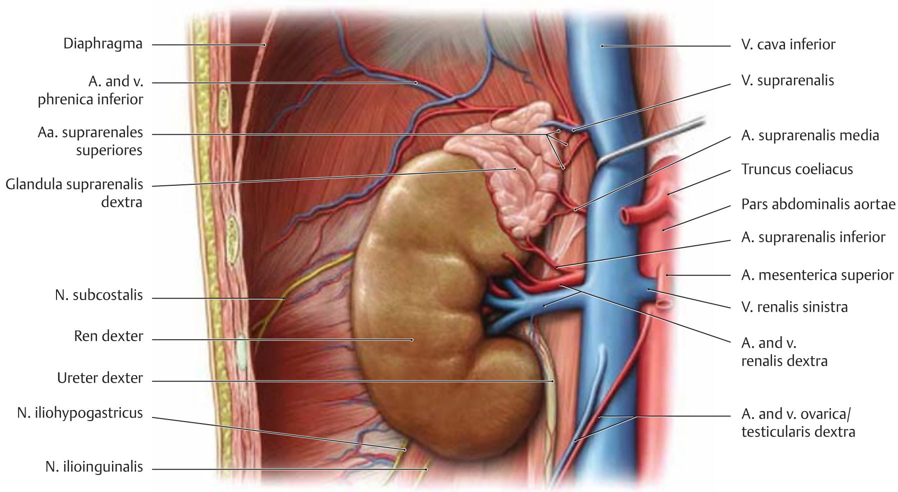
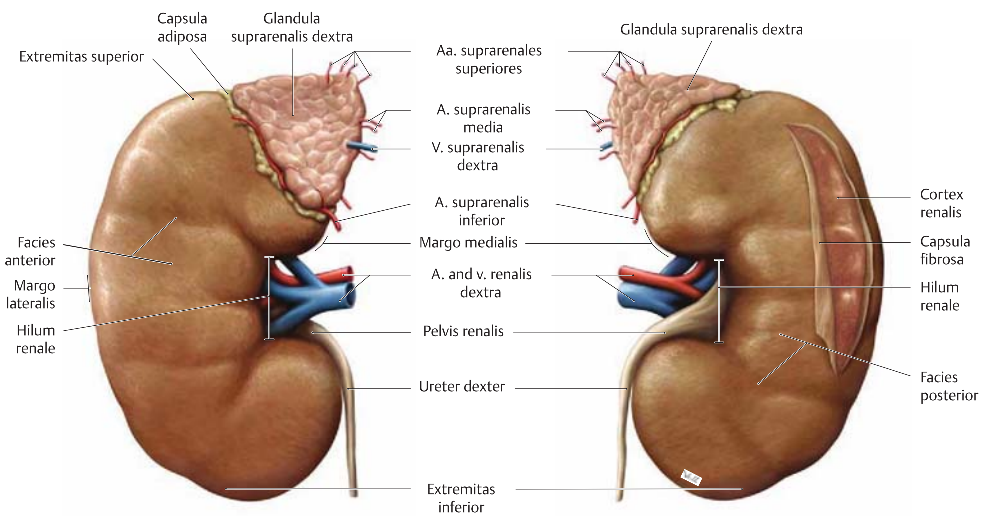


Fig. 13.45 **Ren: Structure**
Ren dexter with gl. suprarenalis.

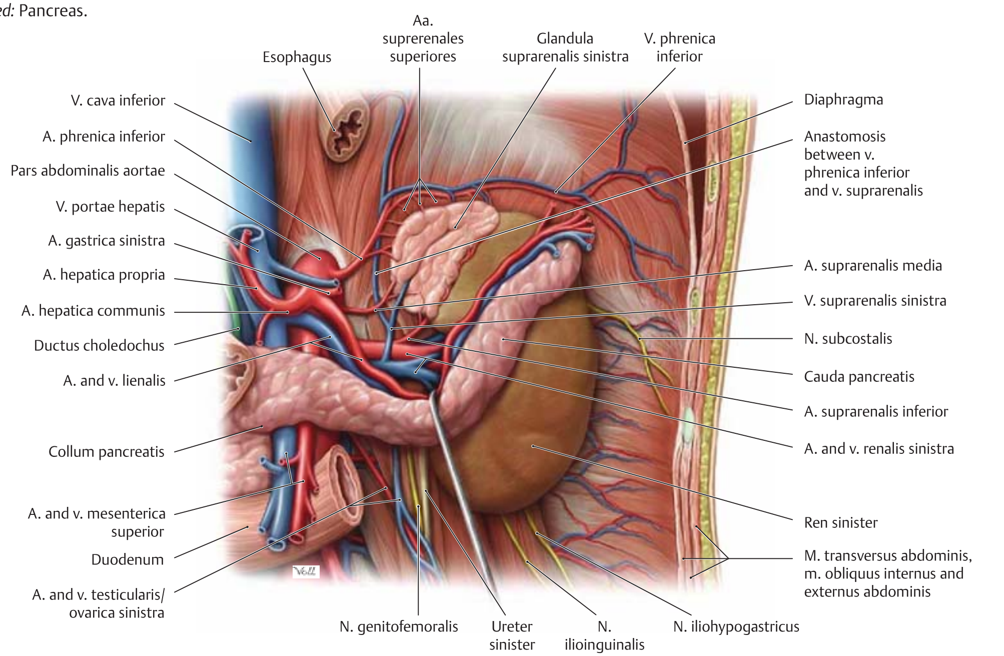


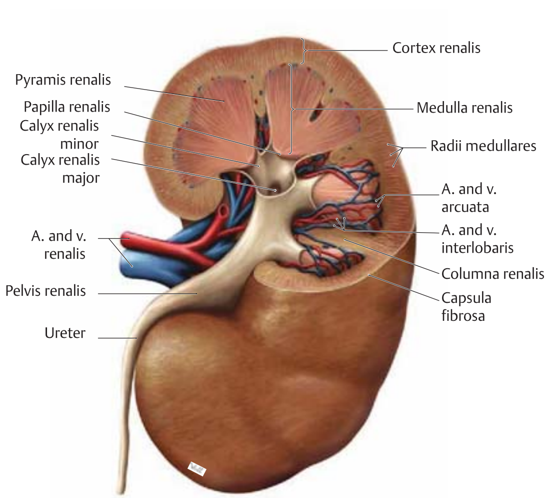
A Anterior view.

B Posterior view.

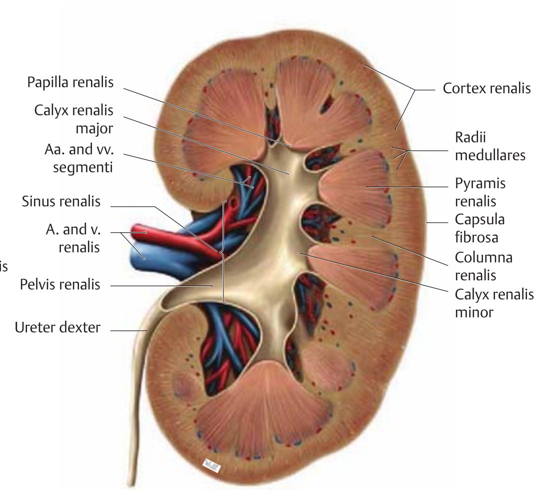
Fig. 13.44 **Ren sinister and gl. suprarenalis**

Anterior view. *Removed:* Capsula adiposa renis.
Retracted: Pancreas.





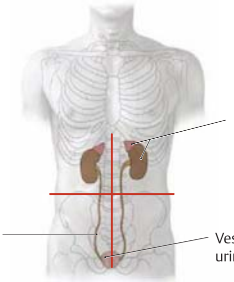
C Posterior view with upper half partially removed.



D Midlongitudinal section, posterior view.

Ureter

Fig. 13.46 **Ureters: Location**
Anterior view.



The ureters cross a. iliaca communis at its bifurcation into aa. iliaca externa and interna.

Fig. 13.47 **Ureters in situ**
Anterior view, male abdomen. *Removed:* Non-urinary organs and rectal stump. The ureters are retroperitoneal.

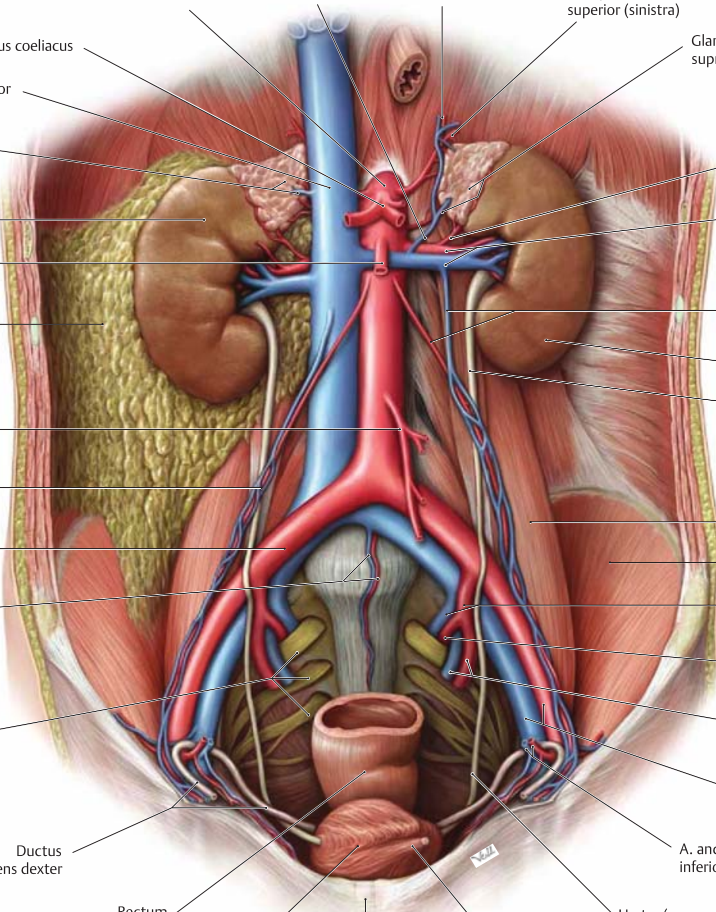


Fig. 13.48 Ureter in the male pelvis

Superior view.

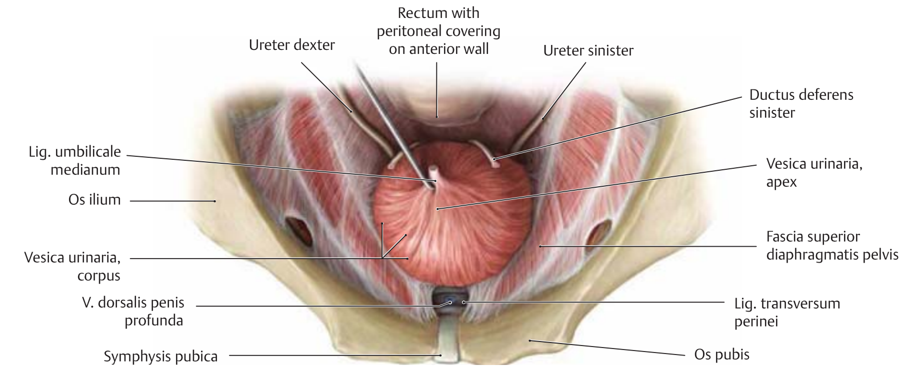
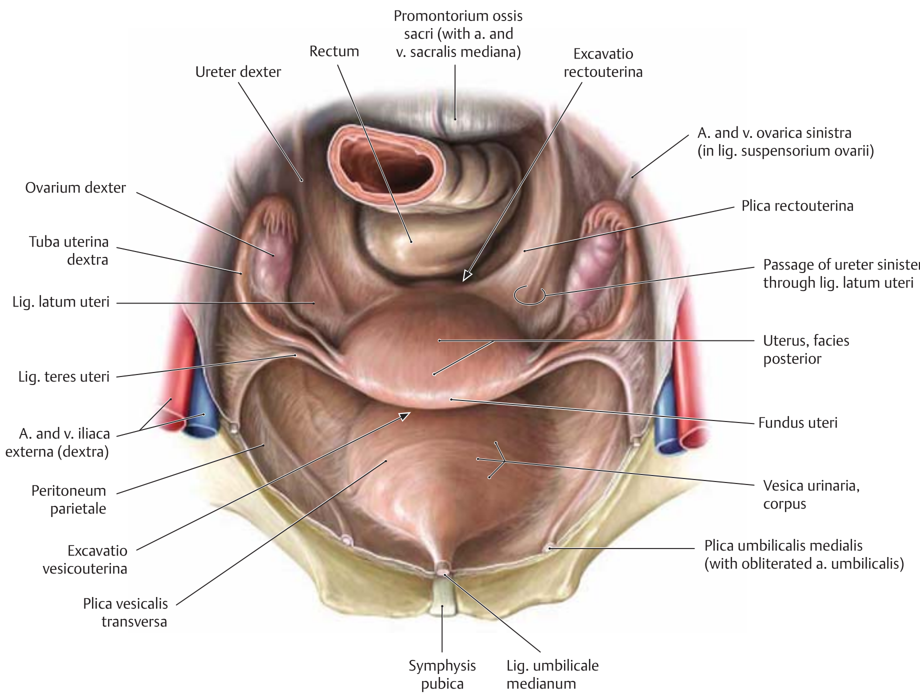


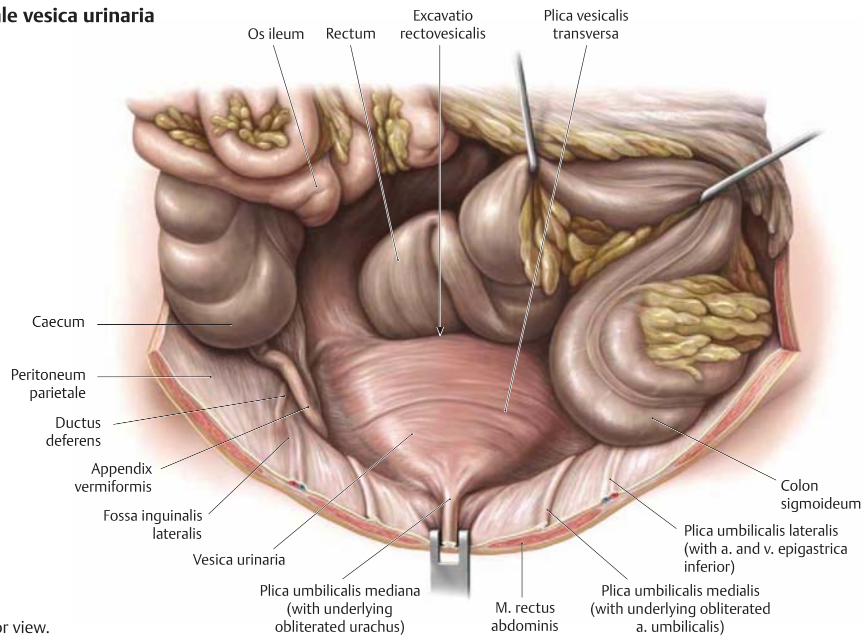
Fig. 13.49 Ureter in the female pelvis

Superior view.

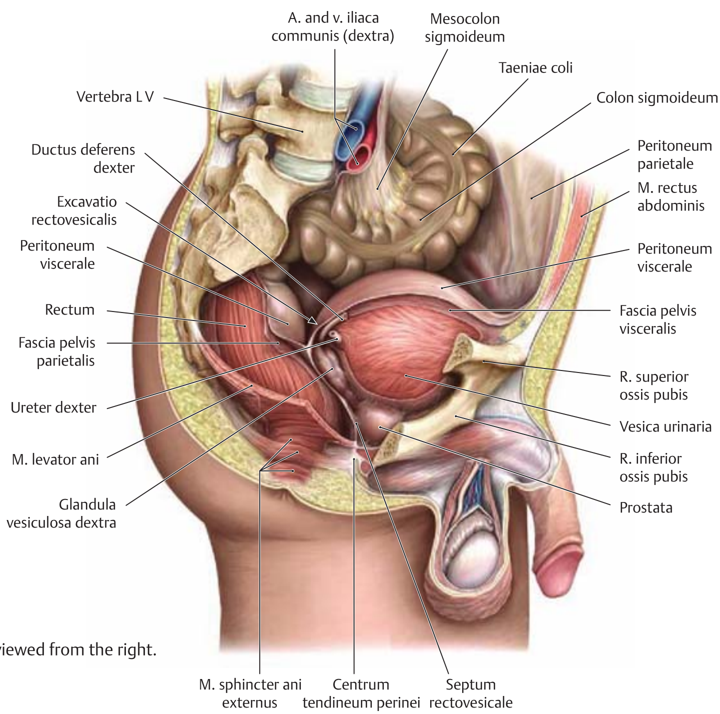


Vesica Urinaria

Fig. 13.50 **Male vesica urinaria**



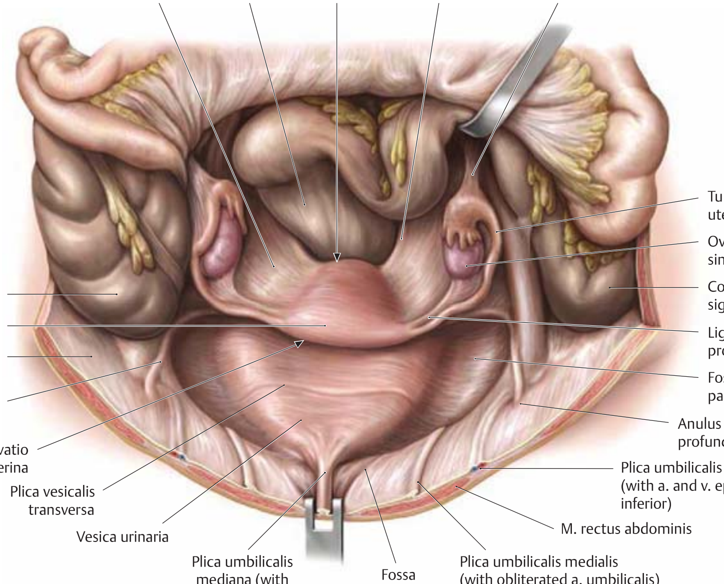
A Anterosuperior view.



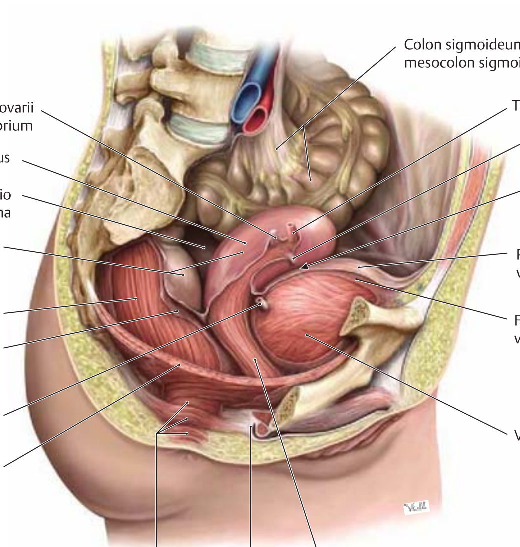
B Parasagittal section, viewed from the right.

Vesica urinaria is retropubic and retroperitoneal in location.

Fig. 13.51 Female vesica urinaria



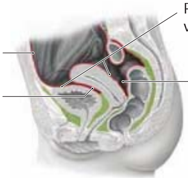
A Anterosuperior view.



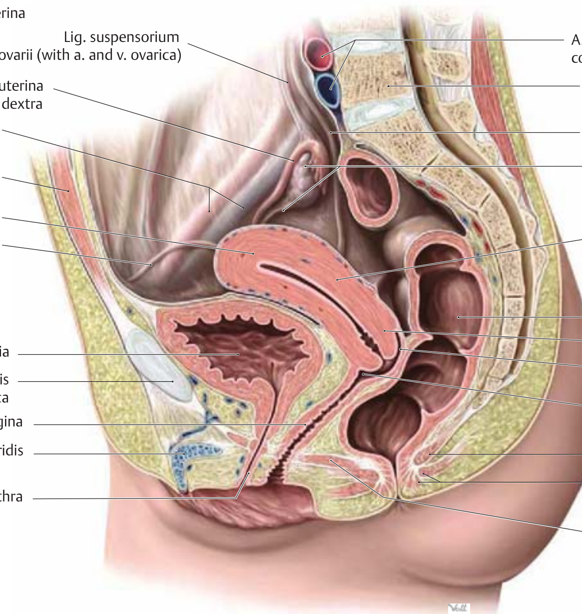
B Parasagittal section, viewed from the right.

Vesica Urinaria & Urethra

Fig. 13.52 **Female vesica urinaria and urethra**
Midsagittal section, viewed from the left side.

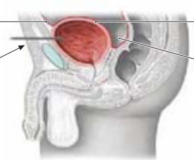


A Peritoneal covering.

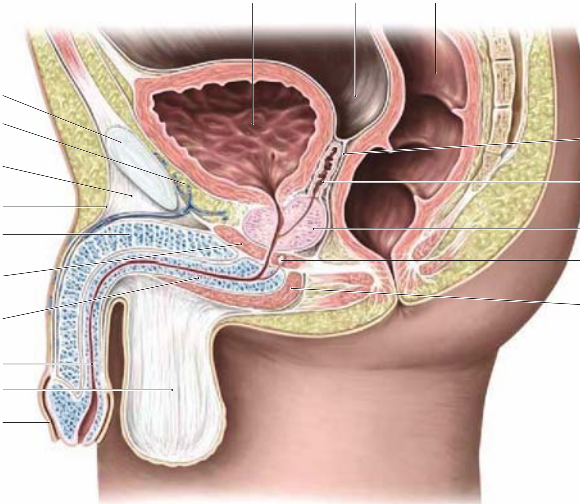


B Right female hemipelvis.

Fig. 13.53 **Male vesica urinaria and urethra**
Midsagittal section, viewed from the left side.



A Peritoneal covering.



B Right male hemipelvis.

Fig. 13.54 **Wallstructure**
Anterior view of coronal section.

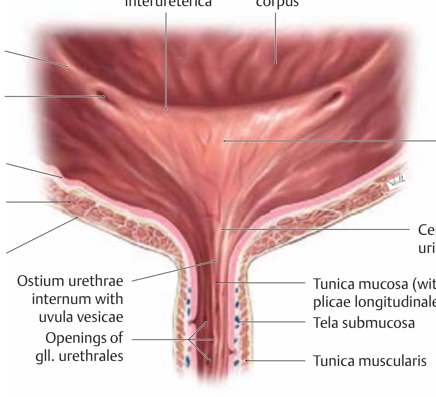
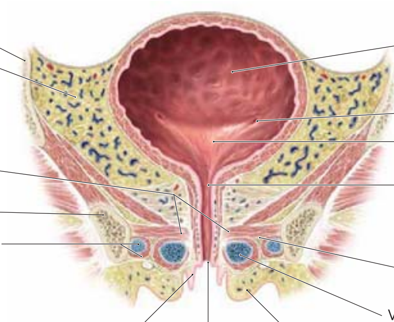
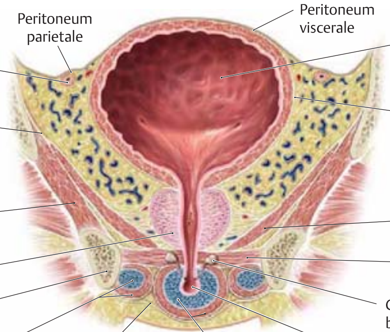


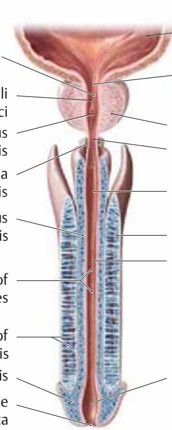
Fig. 13.55 **Vesicaurinaria and urethra**
Anterior view.



A Female pelvis in coronal section.



B Male pelvis in coronal section.



C Male urethra in longitudinal section.

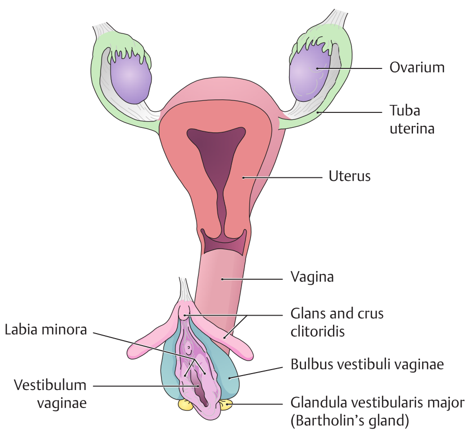
Overview of the Genital Organs

The genital organs can be classified topographically (external versus internal), functionally (Tables 14.1 and 14.2), or ontogenetically (see p. 204).

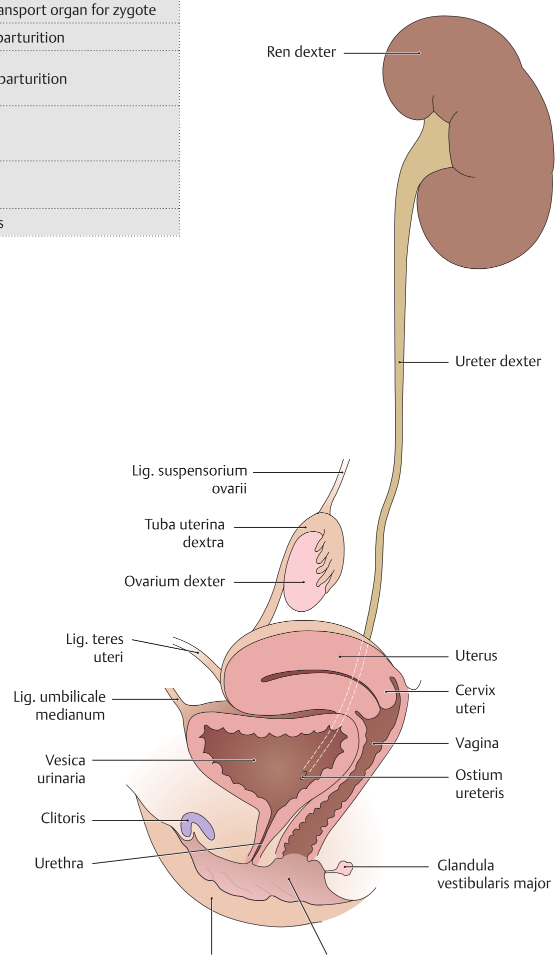
Table 14.1 Female genital organs

	Organ		Function
Internal genitalia	Ovarium		Germ cell and hormone production
	Tuba (fallopii) uterina		Site of conception and transport organ for zygote
	Uterus		Organ of incubation and parturition
	Vagina (pars superior)		Organ of copulation and parturition
External genitalia	Vulva	Vagina (vestibulum)	
		Labia majora and minora	Copulatory organ
		Clitoris	
		Glandula vestibularis minor and major	Production of secretions
		Mons pubis	Protection of the os pubis

Fig. 14.1 **Female genital organs**



A Internal and external genitalia.

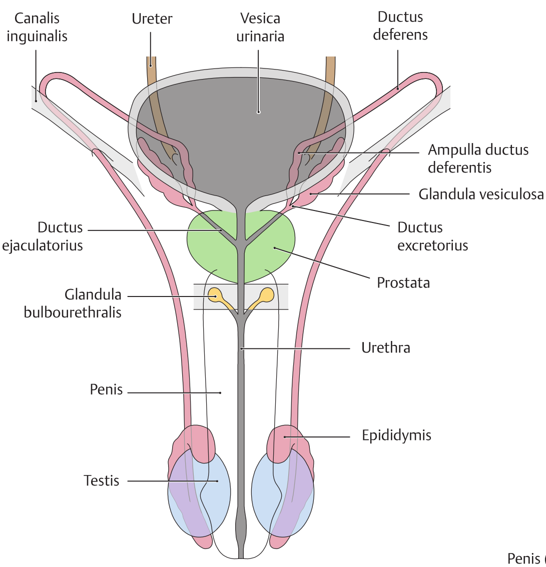


B Urogenital system. *Note:* The female urinary and genital tracts are functionally separate, though topographically close.

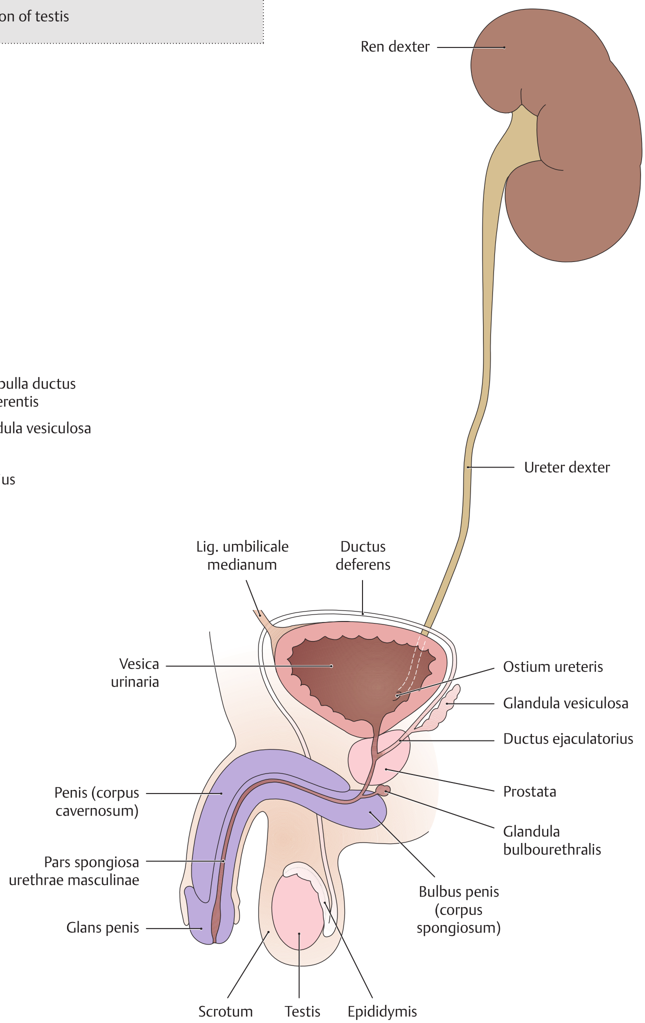
Table 14.2 Male genital organs

	Organ		Function
Internal genitalia	Testis		Germ cell and hormone production
	Epididymis		Reservoir for sperm
	Ductus deferens		Transport organ for sperm
	Accessory sex glands	Prostata	Production of secretions (semen)
		Glandula vesiculosa	
		Glandula bulbourethralis	
External genitalia	Penis		Copulatory and urinary organ
	Urethra		Urinary organ and transport organ for sperm
	Skrotum		Protection of testis
	Coverings of the testis		

Fig. 14.2 **Male genital organs**



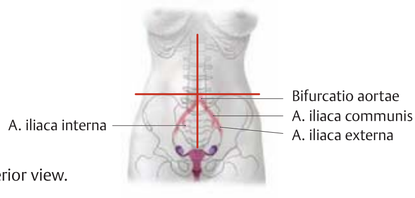
A Seminiferous structures.



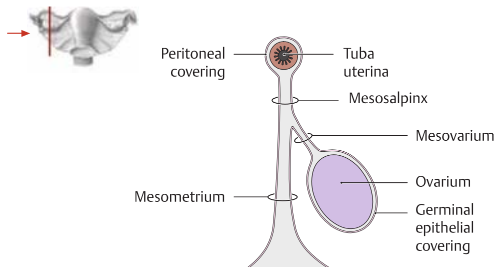
B Urogenital system. *Note:* The male urethra serves as a common urinary and genital passage.

Uterus & Ovaries

Fig. 14.3 **Female internal genitalia**
The uterus and ovaria are suspended by the mesovarium and mesometrium (portions of lig. latum uteri).



A Location. Anterior view.



B Mesenterium. Sagittal section. Lig. latum uteri is a combination of the mesosalpinx, mesovarium, amd mesometrium.

Fig. 14.4 **Ovarium**
Posterior view of ovarium dexter.

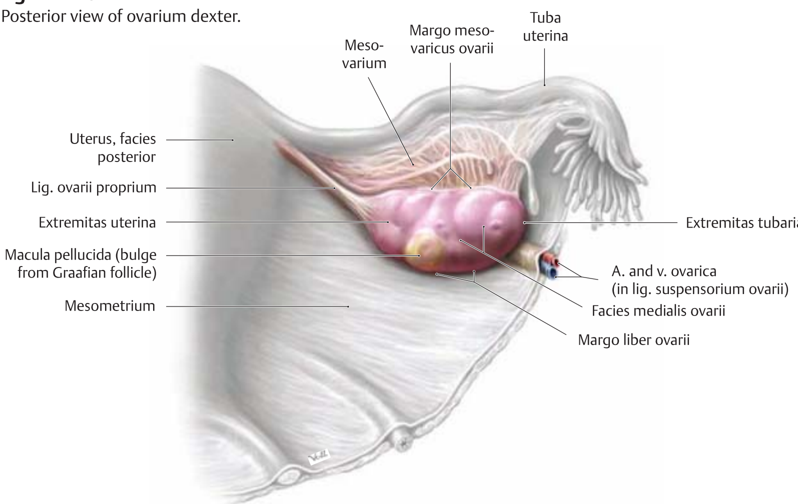
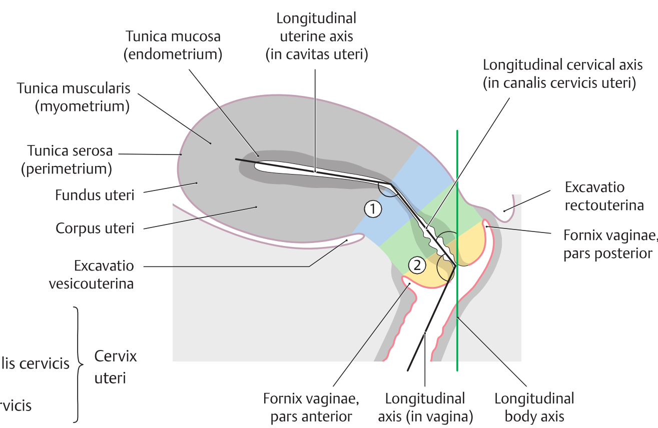


Fig. 14.5 **Curvature of the uterus**
Midsagittal section, left lateral view. The position of the uterus can be described in terms of flexion (①) and version (②).

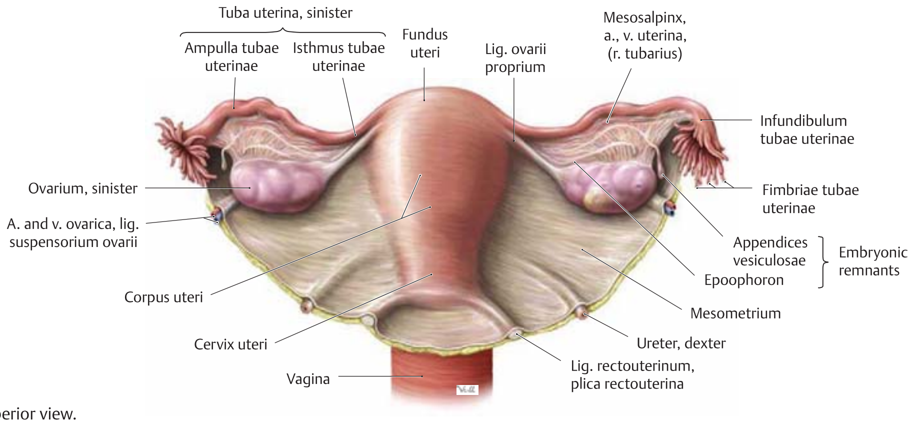


①Flexion: Angle between the corpus uteri and isthmus.

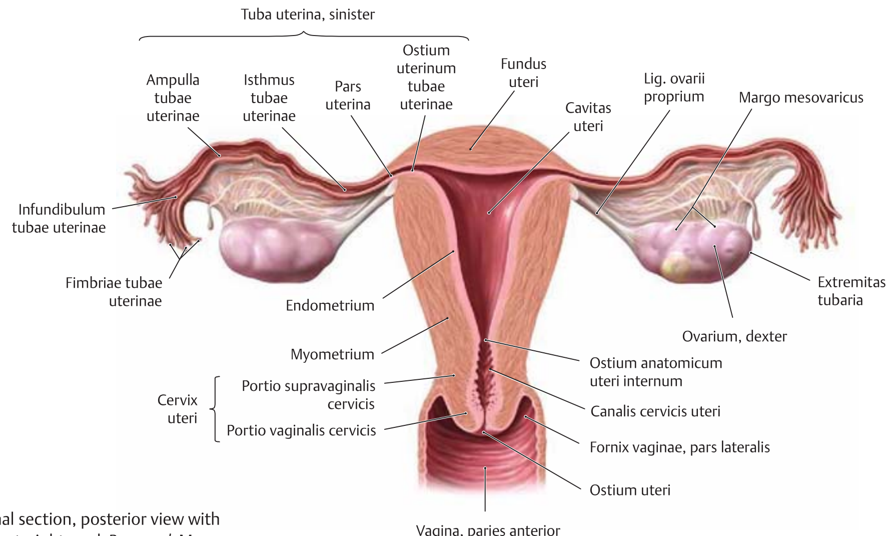
②Version: Angle between canalis cervicis uteri and the vagina.

- Isthmus uteri
- Portio supravaginalis cervicis } Cervix uteri
- Portio vaginalis cervicis } Cervix uteri

Fig. 14.6 **Uterus and tuba uterina**



A Posterosuperior view.



B Coronal section, posterior view with uterus straightened. *Removed:* Mesometrium.

Clinical

Ectopic pregnancy

After fertilization, the ovum usually implants in the wall of the uterine cavity. However, it may become implanted at other sites (e.g., tuba uterina or even the cavitas peritoneale). Tubal pregnancies, the most common type of ectopic pregnancy, pose the risk of tubal wall rupture and potentially life-threatening bleeding into the peritoneal cavity. Tubal pregnancies are promoted by adhesion of the tubal mucosa, mostly due to inflammation.

Vagina

Fig. 14.7 **Location**
Midsagittal section, left lateral view.

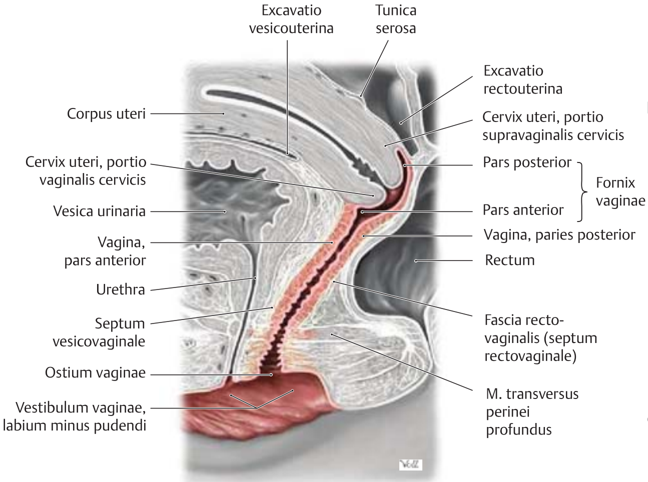


Fig. 14.8 **Structure**
Posteriorly angled coronal section, posterior view.

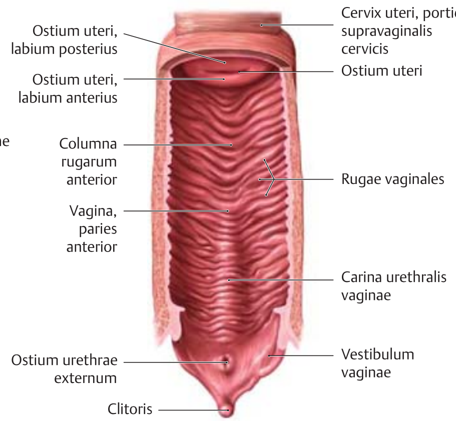


Fig. 14.9 **Cervix uteri: Transverse section**
Inferior view.

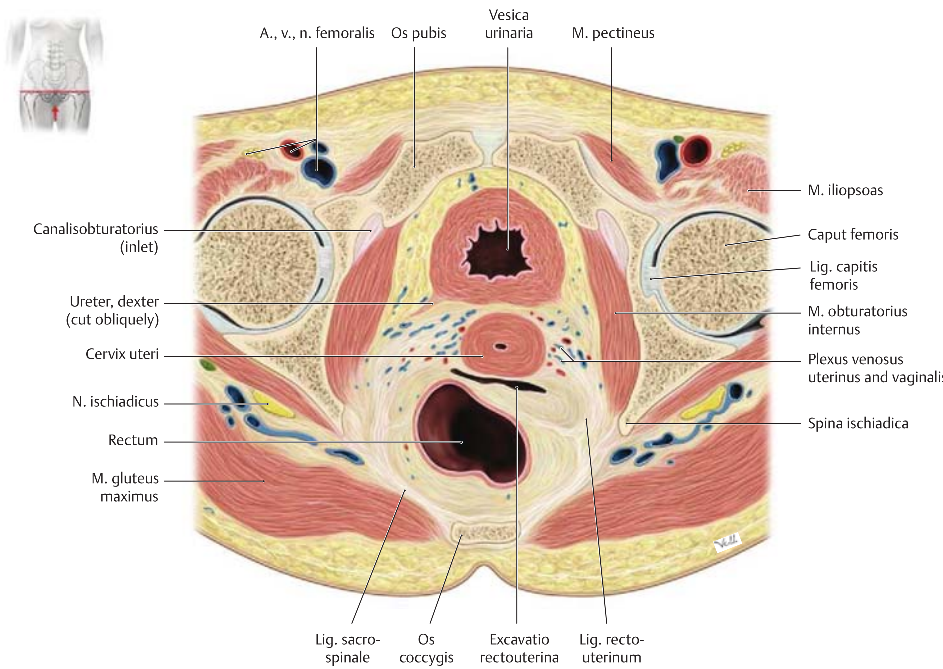


Fig. 14.10 **Female genital organs: Coronal section**
Anterior view. The vagina is both pelvic and perineal in location. It is also retroperitoneal.

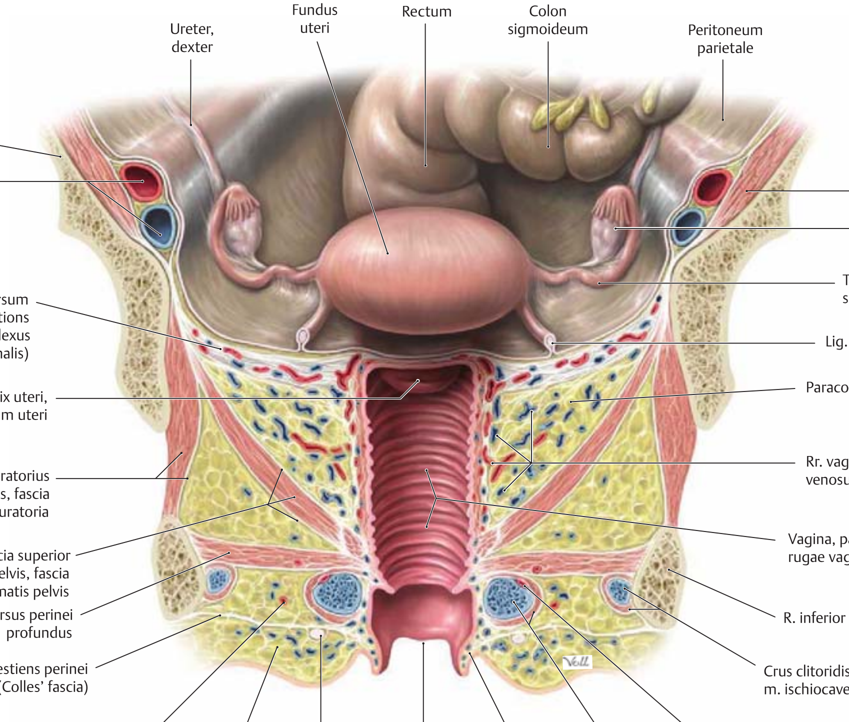
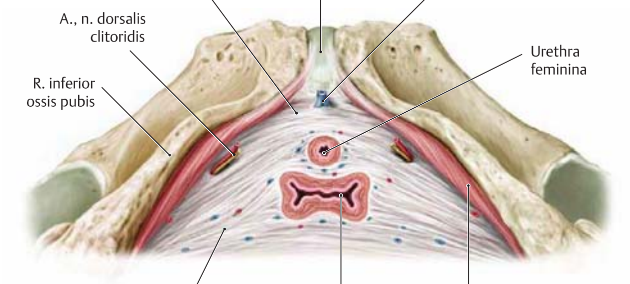


Fig. 14.11 **Vagina: Location in the pelvic floor**
Inferior view.



Female External Genitalia

Fig. 14.12 **Female external genitalia**
Lithotomy position with labia minora separated.

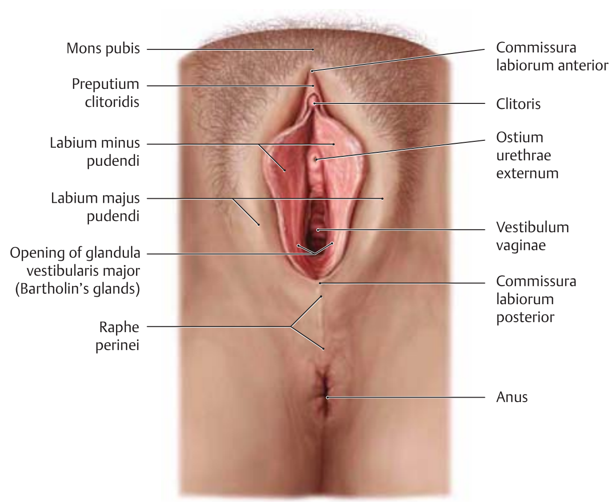


Fig. 14.13 **Vestibulum vaginae and vestibular glands**
Lithotomy position with labia separated.

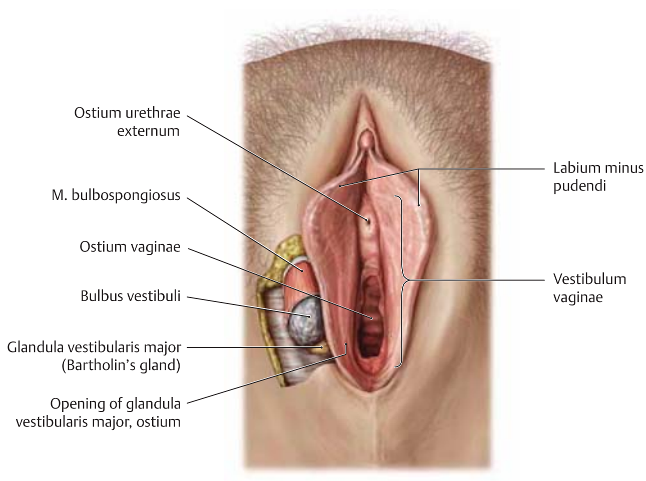
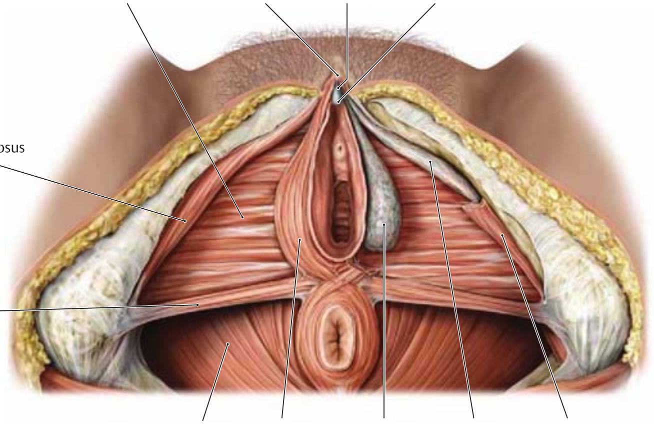


Fig. 14.14 **Erectile muscles and tissue: Female**

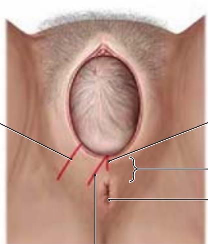
Lithotomy position. *Removed:* Labia, skin, and membrana perinei; erectile muscles (left side).



Clinical

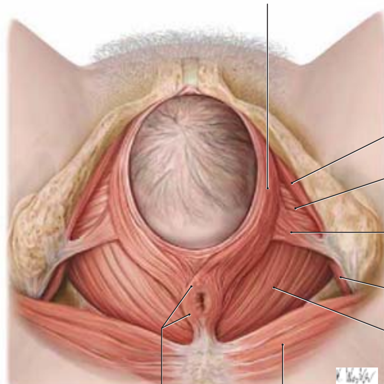
Episiotomy

Episiotomy is a common obstetric procedure used to enlarge the birth canal during the expulsive stage of labor. The procedure is generally used to expedite the delivery of a baby at risk for hypoxia during the expulsive stage. Alternately, if the perineal skin turns white (indicating diminished blood flow), there is imminent danger of perineal laceration, and an episiotomy is often performed. More lateral incisions gain more room, but they are more difficult to repair.



A Types of episiotomy.

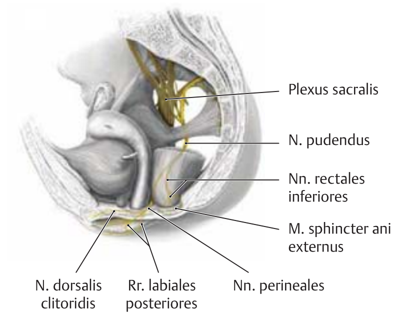
B Mediolateral episiotomy at height of contraction.



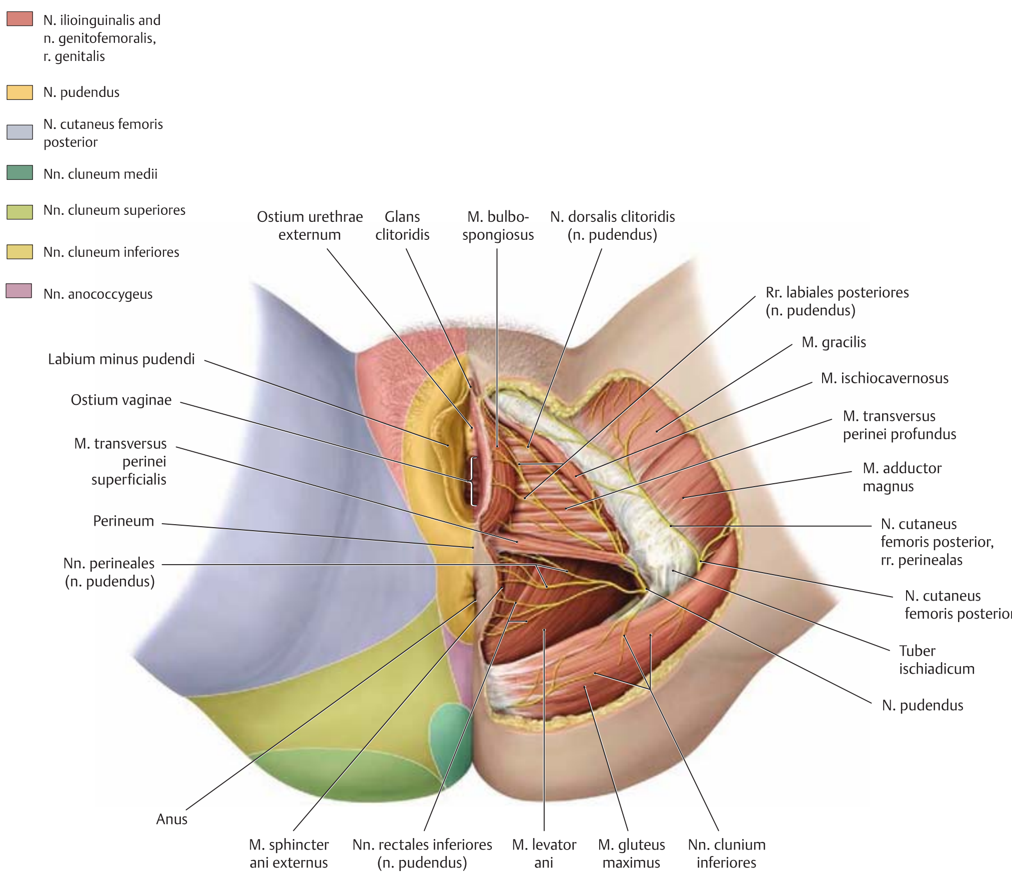
C Pelvic floor with crowning of fetal head.

Neurovasculature of the Female Genitalia

Fig. 14.15 **Nerves of the female perineum and genitalia**

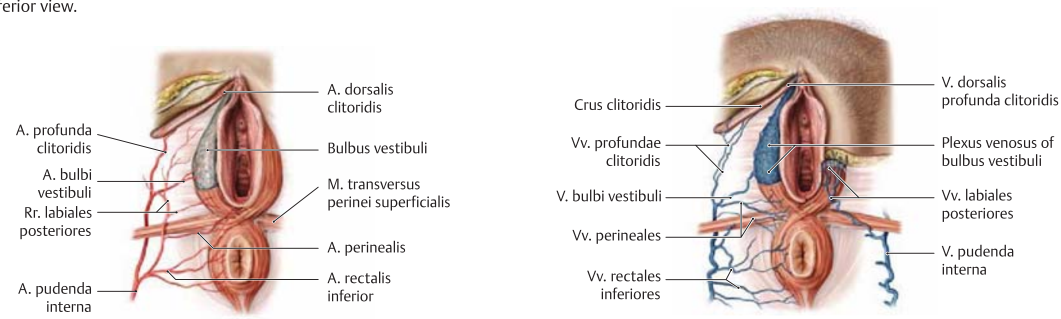


A Nerve supply to the female external genitalia. Lesser pelvis, left lateral view.



B Sensory innervation of the female perineum. Lithotomy position.

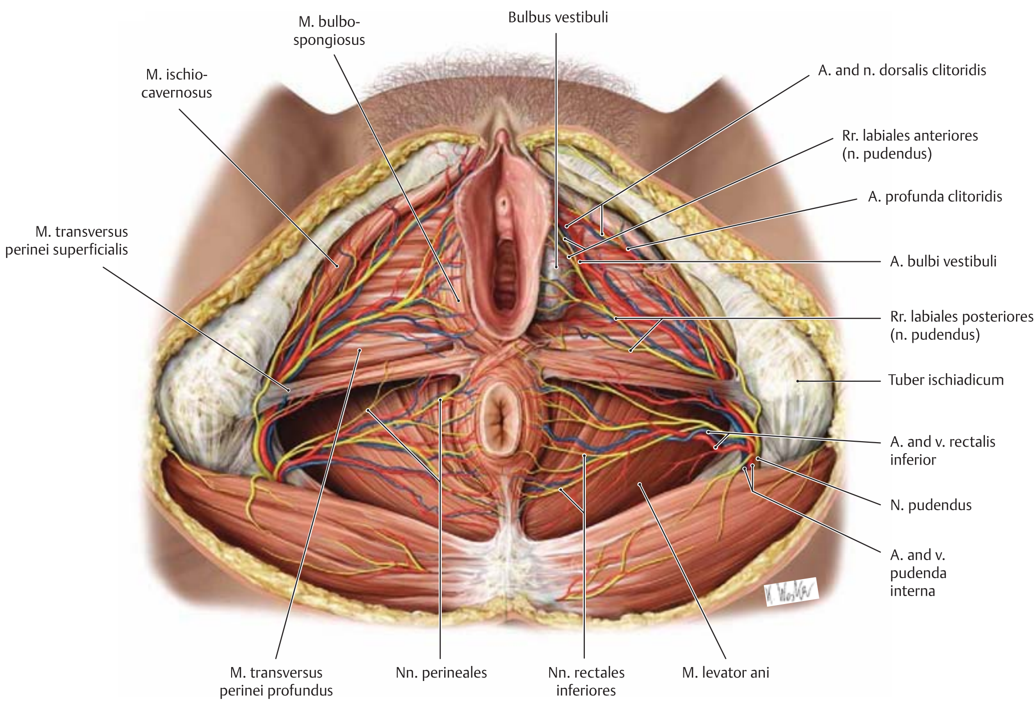
***Fig. 14.16* Blood vessels of the female external genitalia**
Inferior view.



A Arterial supply.

B Venous drainage.

***Fig. 14.17* Neurovasculature of the female perineum**
Lithotomy position.



Penis, Scrotum & Funiculus Spermaticus

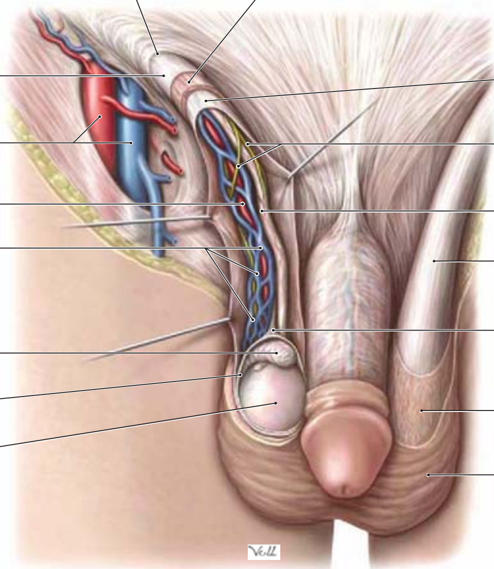


***Fig. 14.18* Penis, scrotum, and funiculus spermaticus**
Anterior view. *Removed:* Skin over the scrotum and funiculus spermaticus.

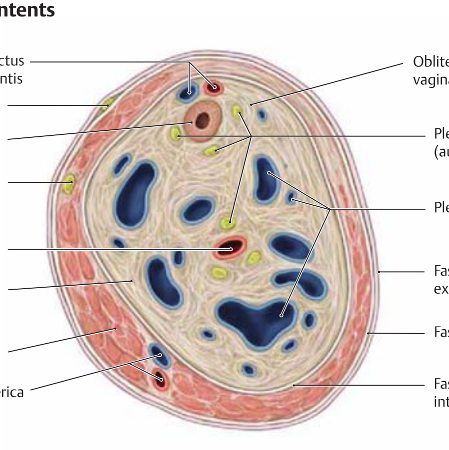
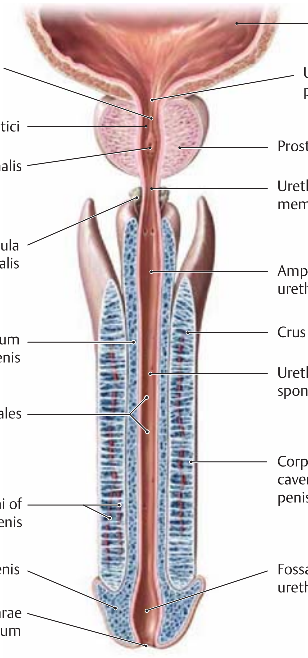
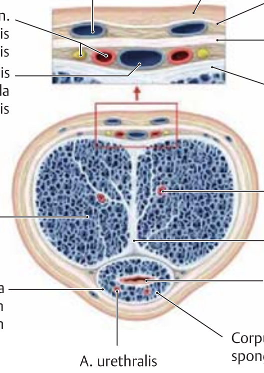


***Fig. 14.19* Funiculus spermaticus: Contents**
Cross section.

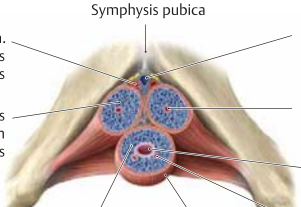
Fig. 14.20 Penis



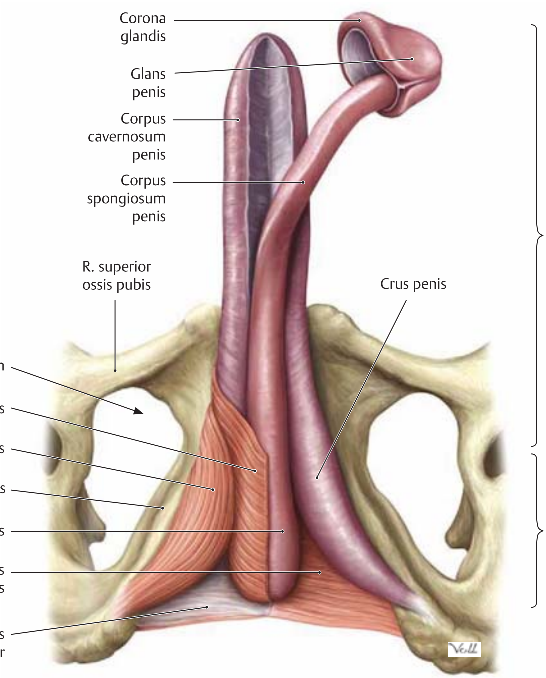
A Longitudinal section.



B Cross section through corpus penis.



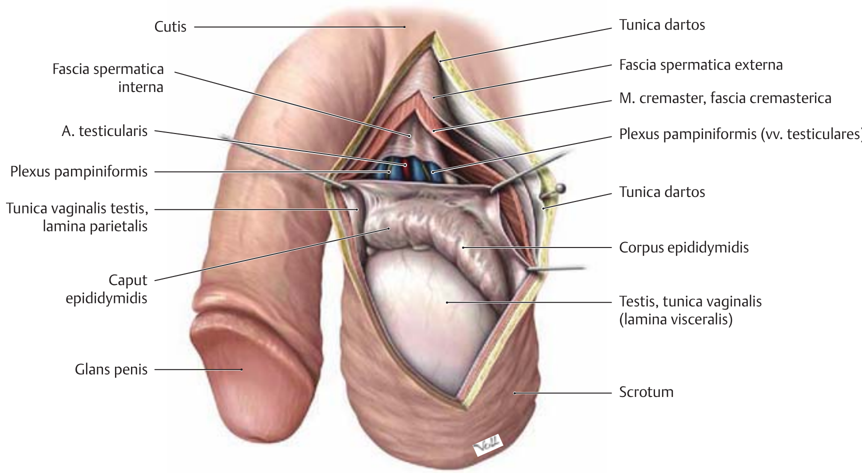
C Cross section through radix penis.



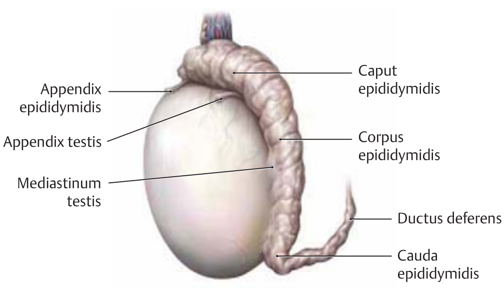
D Inferior view.

Testis & Epididymis

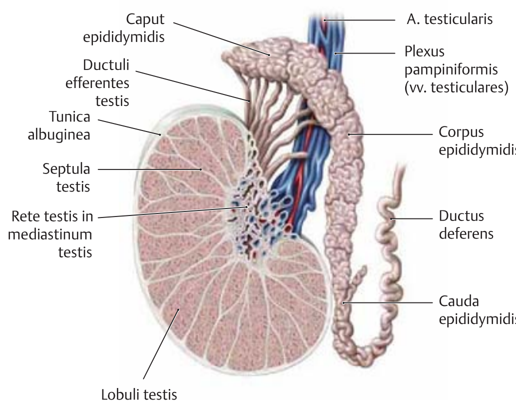
Fig. 14.21 **Testis and epididymis**
Left lateral view.



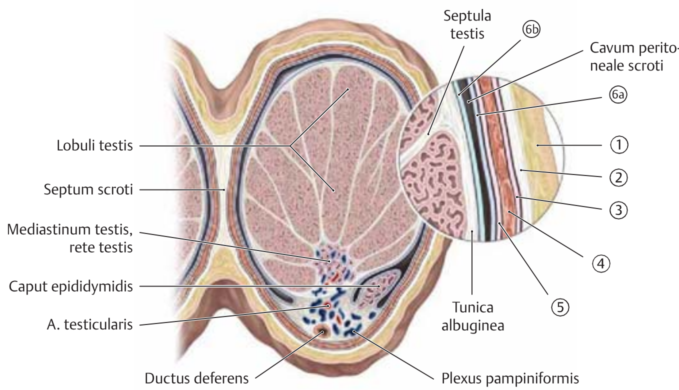
A Testis and epididymis in situ.



B Surface anatomy of the testis and epididymis.



C Sagittal section.



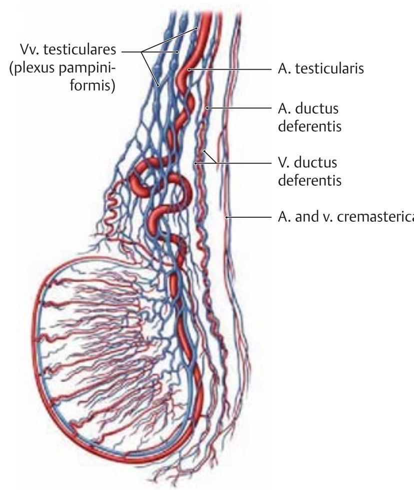
Transverse section through right testis, superior view.

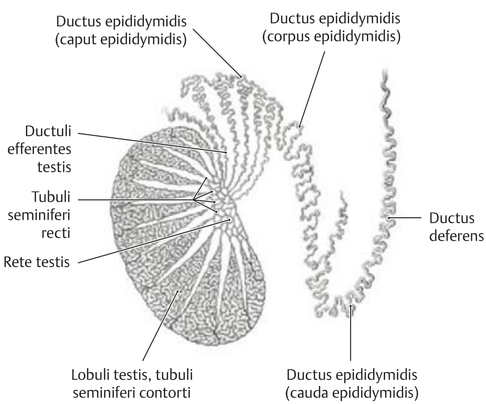
Table 14.3 Coverings of the testis

	Covering of the testis	Abdominal wall derivative
①	Scrotal skin	Abdominal skin
②	Tunica dartos	Fascia dartos and muscle
③	Fascia spermatica externa	M. obliquus externus abdominis
④	Musculus cremaster and fascia*	M. obliquus internus abdominis
⑤	Fascia spermatica externa	Fascia transversalis
6a	Tunica vaginalis, lamina parietalis	Peritoneum
6b	Tunica vaginalis, lamina visceralis	

* The transversus abdominis has no contribution to the spermatic cord or covering of the testis.

Fig. 14.22 **Blood vessels of the testis**
Left lateral view.



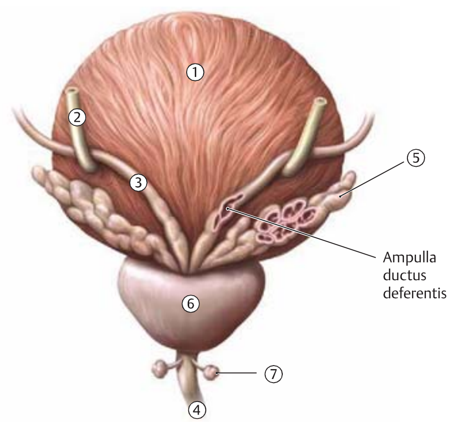


D Tubuli seminiferi.

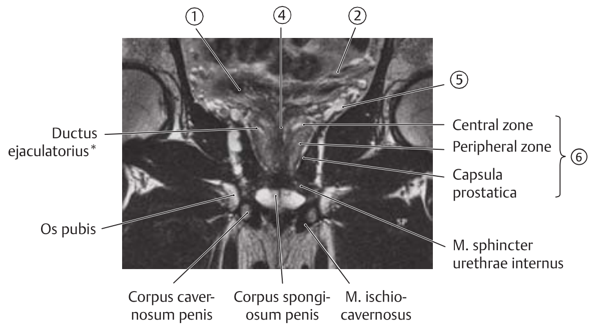
Male Accessory Sex Glands

Fig. 14.23 Accessory sex glands

① Vesica urinaria	⑤ Glandula vesiculosa
② Ureter, pars spongiosa	⑥ Prostata
③ Ductus deferens	⑦ Glandula bulbourethralis
④ Urethra	



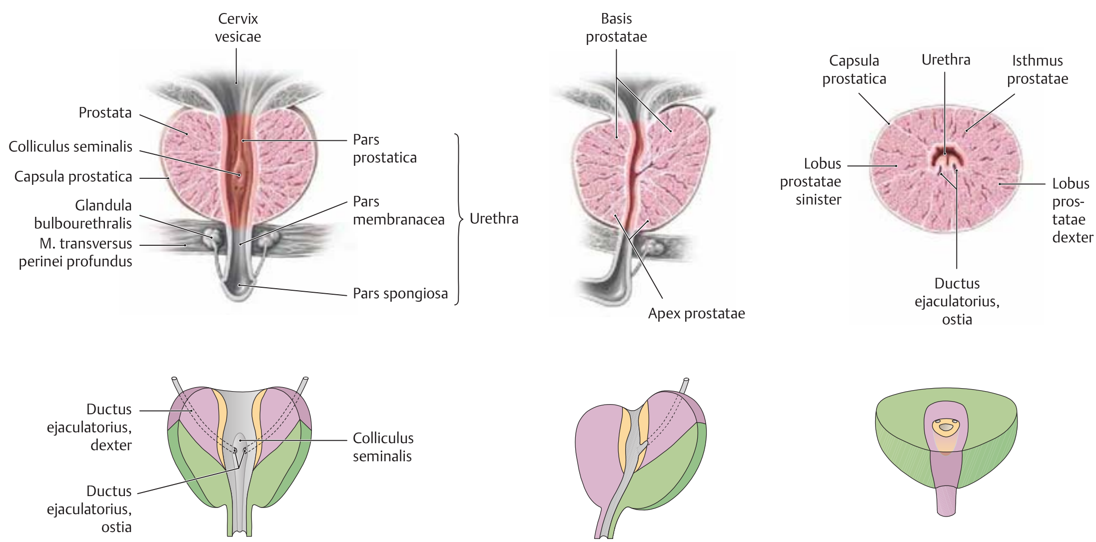
A Posterior view.



*The ducts of the seminal vesicle and ductus deferens combine to form the ejaculatory duct.

B MRI. Coronal section, anterior view.

Fig. 14.24 Prostata
The prostata may be divided anatomically (top row) or clinically (bottom row).



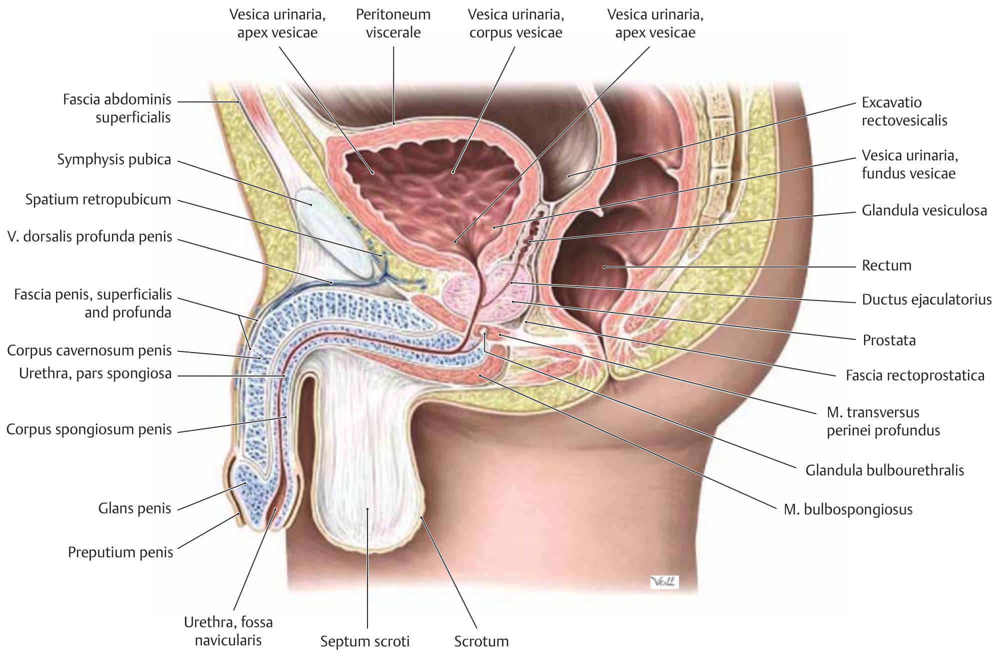
A Coronal section, anterior view.

B Sagittal section, left lateral view.

C Transverse section, superior view.

Peripheral zone (outer zone) | Central zone (inner zone) | Periurethral zone

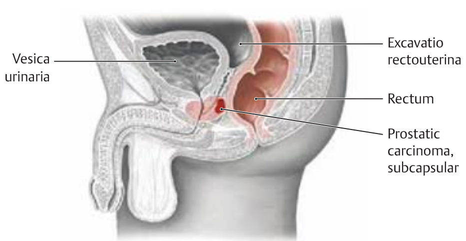
Fig. 14.25 **Prostata in situ**
Sagittal section through the male pelvis, left lateral view.



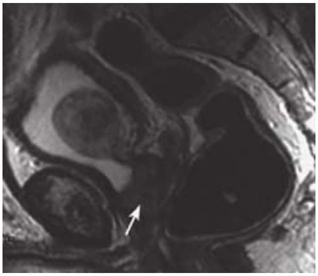
Clinical

Prostatic carcinoma and hypertrophy

Prostatic carcinoma is one of the most common malignant tumors in older men, often growing at a subcapsular location in the peripheral zone of the prostate. Unlike benign prostatic hyperplasia, which begins in the central part of the gland, prostatic carcinoma does not cause urinary outflow obstruction in its early stages. Being in the peripheral zone, the tumor is palpable as a firm mass through the anterior wall of the rectum during rectal examination.



A Common site of prostatic carcinoma.

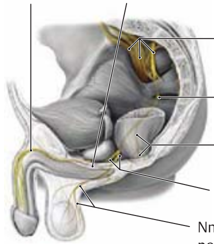


B Prostatic carcinoma (arrow) with bladder infiltration.

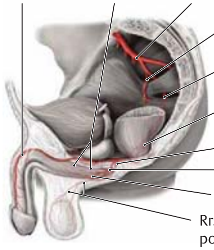
In certain prostate diseases, especially cancer, increased amounts of a protein, prostate-specific antigen or PSA, appear in the blood. This protein can be measured by a simple blood test.

Neurovasculature of the Male Genitalia

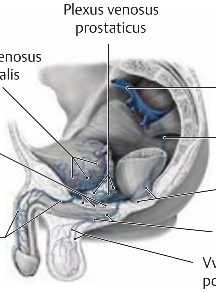
Fig. 14.26 **Neurovasculature of the male genitalia**
Left lateral view.



A Nerve supply.

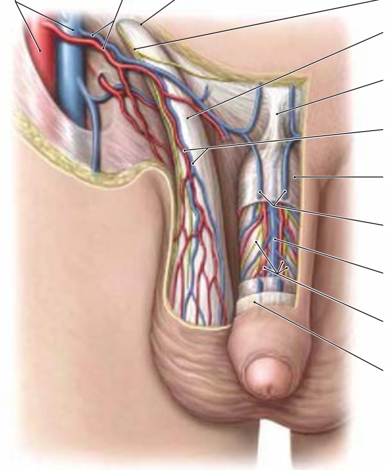


B Arterial supply.

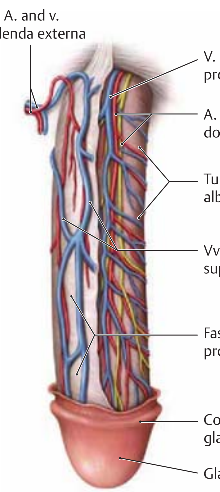


C Venous drainage.

Fig. 14.27 **Neurovasculature of the penis and scrotum**



A Anterior view. *Partially removed:* Skin and fascia.



B Dorsal vasculature of the penis.

Fig. 14.28 Nerves of the male perineum and genitalia
Lithotomy position.

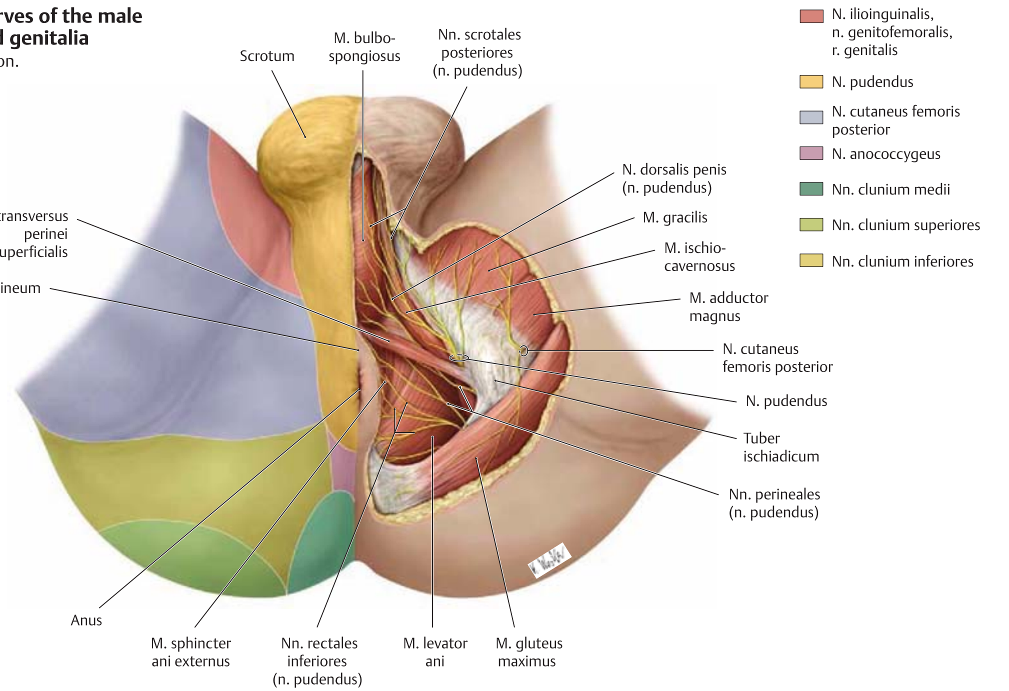
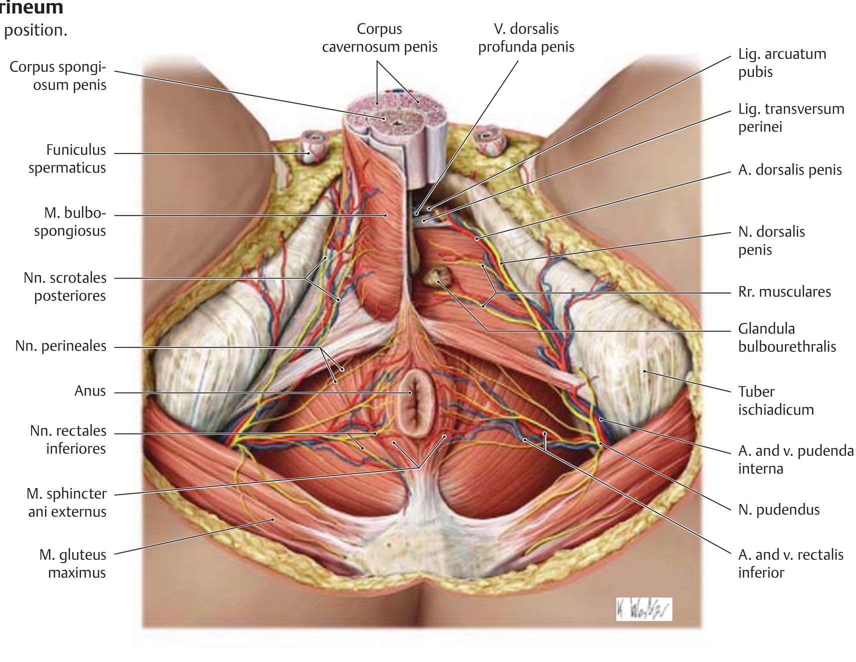


Fig. 14.29 Neurovasculature of the male perineum
Lithotomy position.



Development of the Genitalia

The male and female genitalia are derived from a common gonadal primordium.

Fig. 14.30 Development of the external genitalia

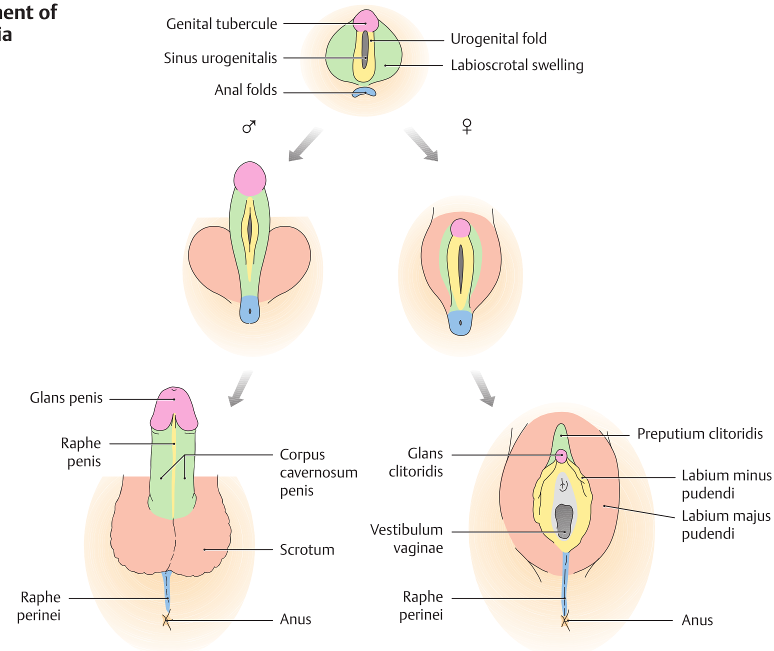
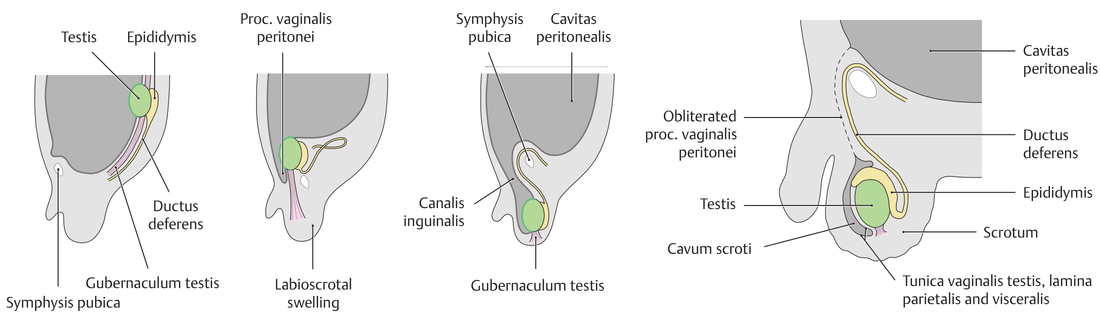


Fig. 14.31 Descent of the testis
Left lateral view.



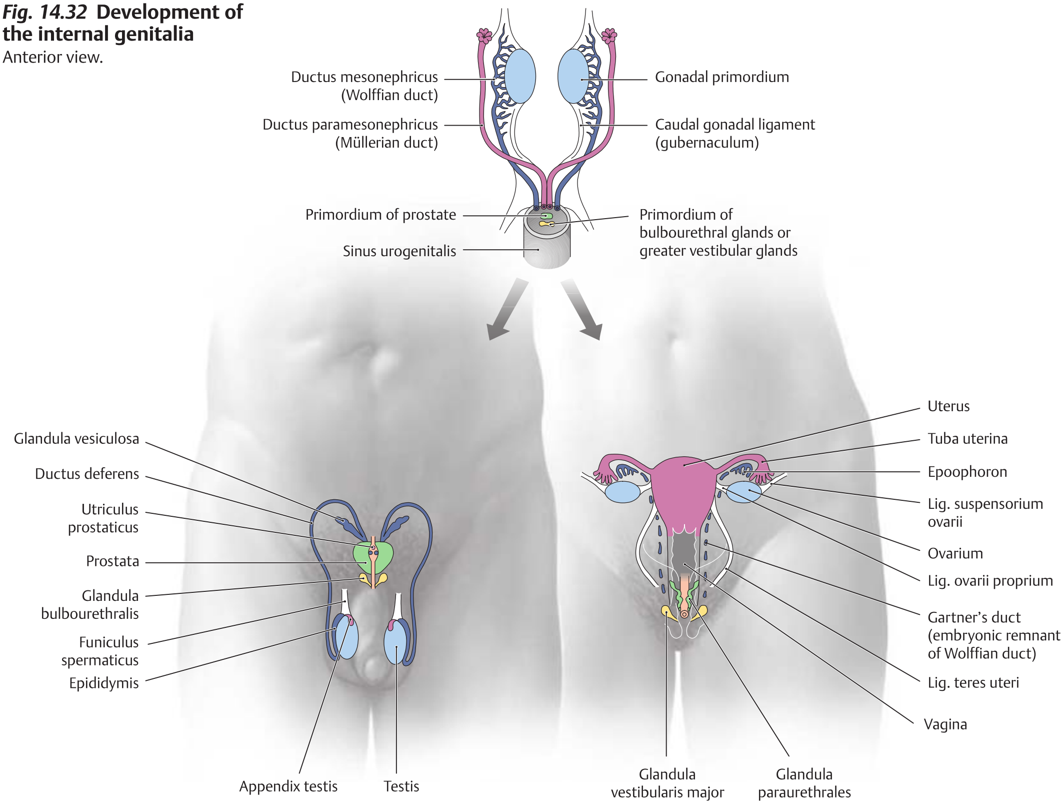
A 2nd month of development.

B 3rd month.

C Birth.

D After obliteration of the processus vaginalis of the peritoneum.

Fig. 14.32 **Development of the internal genitalia**
Anterior view.



A Genetically male embryo (testicular primordium).

B Genetically female embryo (ovarian primordium).

Table 14.4 **Derivatives of embryonic urogenital structures**

Nonfunctioning remnants in italics. Structures common to both sexes in bold.

Rudiment	Male structure	Female structure
Undifferentiated gonad	Testis	Ovarium
Cortex	Tubuli seminiferi	Folliculi
Medulla	Rete testis	Stroma ovarii
Mesonephric ductule	Ductuli efferentis testis, *paradidymis*	*Epo- and paroöphoron*
Mesonephric (Wolffian) duct	**Ureter, pelvis renalis and calices, collecting ducts**	
	Ductus epididymidis, ductus deferens, ductus ejaculatorius, glandula vesiculosa	–
Paramesonephric (Müllerian) duct	*Appendix testis*	Tuba uterina, uterus, vagina (superior portion), *Morgagni's hydatids*
Sinus urogenitalis	**Vesica urinaria, urethra**	
	Prostata, glandula bulbourethralis, *utriculus prostaticus*	Vagina (inferior portion), glandula vestibularis minor and major
Phallus (tuberculum genitalis)	Corpus cavernosum penis	Clitoris, glans clitoridis
Genital folds	Glans of penis, *raphe penis*	Labia minora, *bulbus vestibularis*
Labioscrotal swellings	Skrotum	Labia majora
Gubernaculum	*Gubernaculum testis*	Lig. ovarium proprium, lig. teres uteri
Tuberculum genitalis (of Müller)	*Colliculus seminalis*	*Hymen*

Arteries of the Abdomen

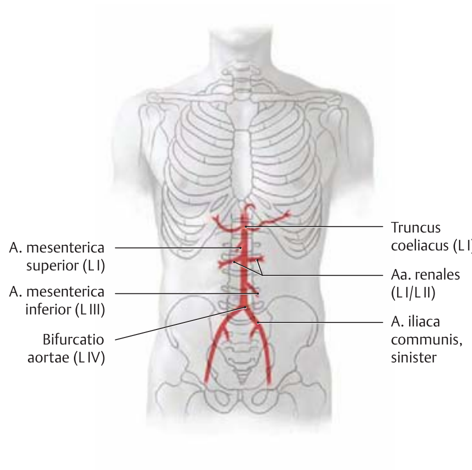


Fig. 15.1 Aorta abdominalis and major branches
Anterior view. The aorta abdominalis enters the abdomen at the T XII level through hiatus aortae of the diaphragm (see p. 54). Before bifurcating at L IV into its terminal branches, a. iliaca communis, the aorta abdominalis gives off a. renalis (see p. 209) and three major trunks that supply the organs of the alimentary canal:

Truncus coeliacus: Supplies the structures of the foregut, the anterior portion of the alimentary canal. The foregut consists of the esophagus (distal half), gaster, duodenum (proximal half), hepar, vesica biliaris, and pancreas (superior portion).

A. mesenterica superior: Supplies the structures of the midgut: the duodenum (distal half), jejunum and ileum, cecum and appendix, colon ascendens and transversum, and right colic (hepatic) flexure.

A. mesenterica inferior: Supplies the structures of the hindgut: the colon transversum (distal third), left colic (splenic) flexure, colon descendens and sigmoiden, rectum, and canalis analis (upper part).

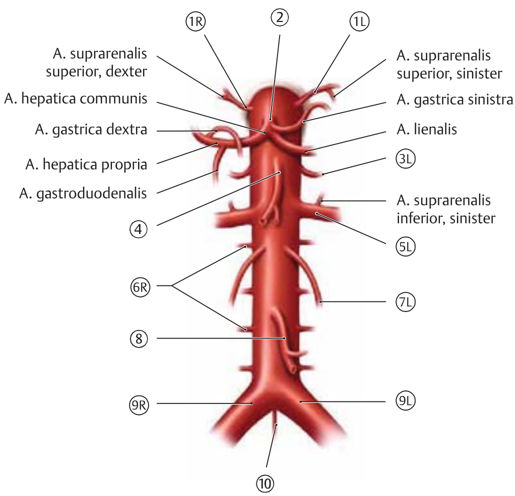
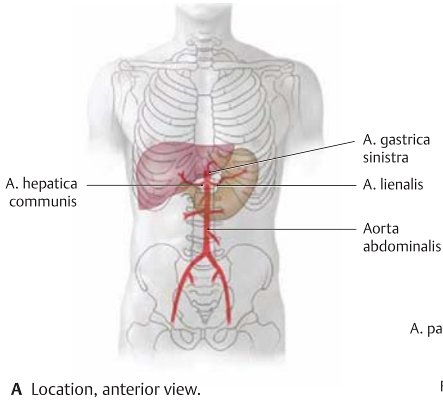


Table 15.1 Branches of the aorta abdominalis

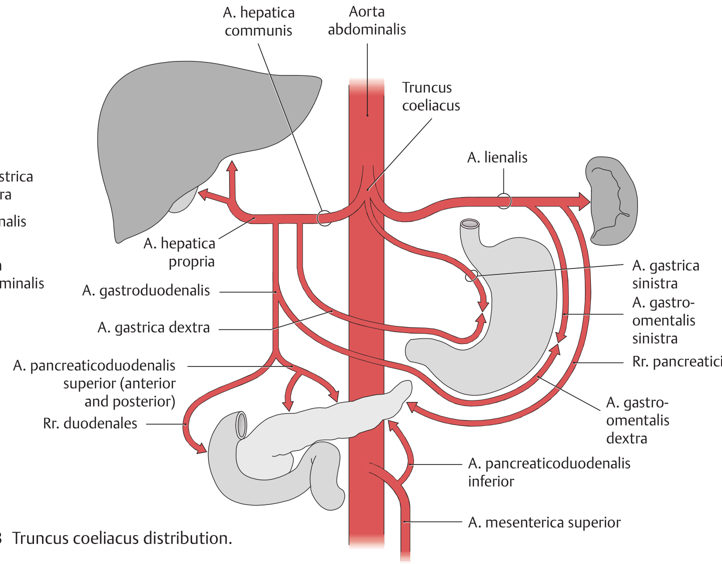
The aorta abdominalis gives rise to three major unpaired trunks (bold) and the unpaired a. sacralis mediana, as well as six paired branches.

		Branch from aorta abdominalis	Branches	
1R	1L	A. phrenica inferior (paired)	A. suprarenalis superior	
2		**Truncus coeliacus**	A. gastrica sinister	
			A. lienalis	
			A. hepatica communis	A. hepatica propria
				A. gastrica dextra
				A. gastroduodenalis
3R	3L	A. suprarenalis media (paired)		
4		**A. mesenterica superior**		
5R	5L	A. renalis (paired)	A. suprarenalis inferior	
6R	6L	Aa. lumbales (1st through 4th, paired)		
7R	7L	A. testicularis/ovarica (paired)		
8		**A. mesenterica inferior**		
9R	9L	A. iliaca communis (paired)	A. iliaca externa	
			A. iliaca interna	
10		A. sacralis mediana		

Fig. 15.2 Truncus coeliacus



A Location, anterior view.



B Truncus coeliacus distribution.

Fig. 15.3 A. mesenterica superior

Anterior view.

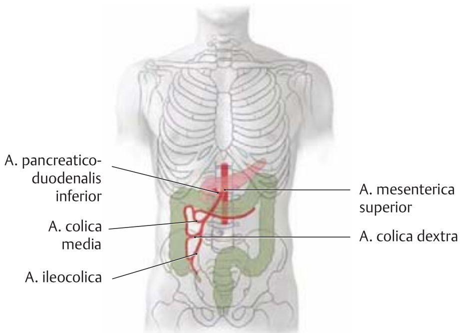


Fig. 15.4 A. mesenterica inferior

Anterior view.

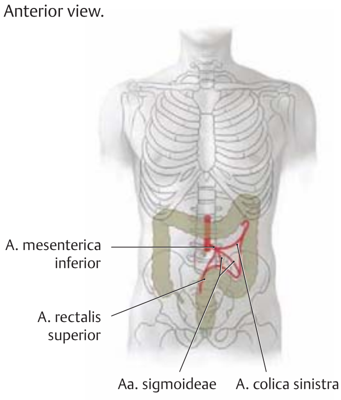


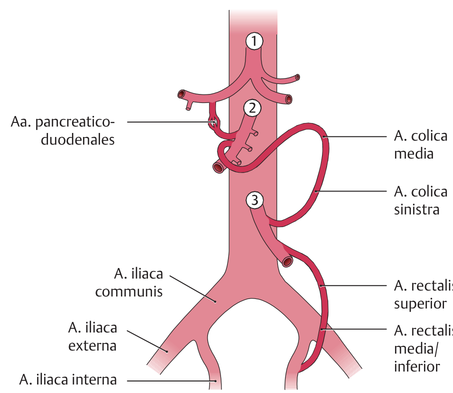
Fig. 15.5 Aorta abdominalis anastomoses

The three major arterial anastomoses of the abdomen deliver blood to intestinal areas deprived of their normal blood supply.

① Truncus coeliacus (supplies the foregut)
- Oesophagus
- Gaster
- Hepar
- Vesica biliaris
- Pancreas
- Duodenum

② A. mesenterica superior (supplies the midgut)
- Pancreas
- Duodenum
- Jejunum and ileum
- Caecum and appendix vermiformis
- Colon ascendens
- Flexura coli hepatica/dextra
- Colon transversum

③ A. mesenterica inferior (supplies the hindgut)
- Colon transversum
- Flexura coli splenica/sinistra
- Colon descendens and sigmoideum
- Rectum
- Canalis analis



Aorta Abdominalis & Arteriae Renales

Fig. 15.6 Aorta abdominalis
Anterior view of the female abdomen. *Removed:* Abdominal organs and peritoneum. The aorta abdominalis is the distal continuation of the aorta thoracica (see p. 68). It enters the abdomen at the T XII level and bifurcates into a. iliaca communis at L IV.

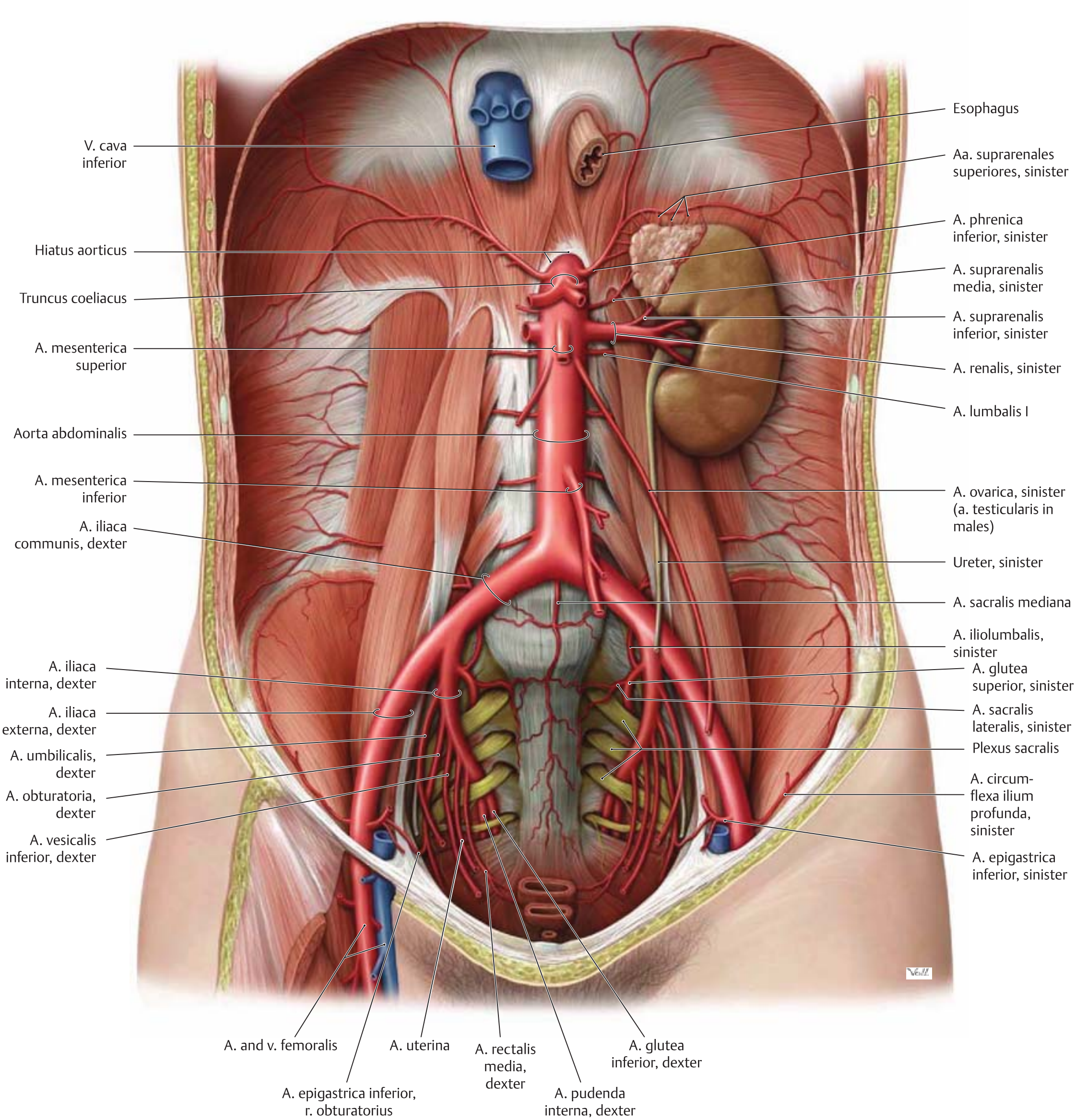
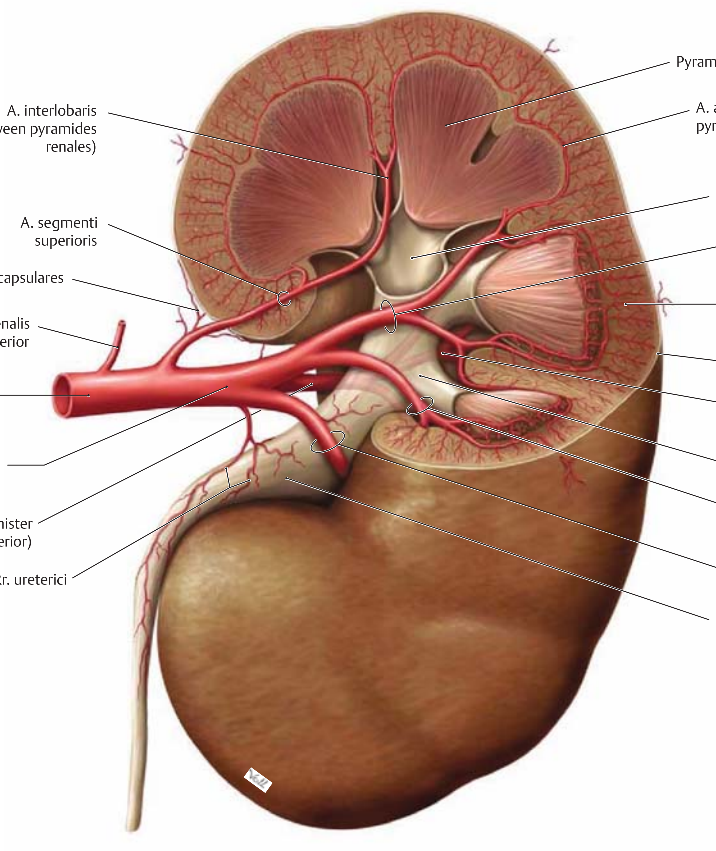


Fig. 15.7 **Arterine renales**
Ren sinister, anterior view. Aa. renales arise at approximately the level of L II. Each renal artery divides into an anterior and a posterior rami. The anterior rami further divides into four segmental arteries (circled).



Clinical

Renal hypertension
The kidney is an important blood pressure sensor and regulator. Stenosis of a. renalis reduces blood flow through the kidney and stimulates increased production of renin, a hormone that cleaves angiotensinogen to form angiotensin I. Subsequent cleavage yields angiotensin II, which induces vasoconstriction and an increase in blood pressure. Renal hypertension must be excluded (or confirmed) when diagnosing high blood pressure.

Stenosis of a. renalis (arrow), visible via arteriography.

Truncus Coeliacus

The distribution of truncus coeliacus is shown on p. 207.

Fig. 15.8 **Truncus coeliacus: Gaster, hepar, and vesica biliaris**
Anterior view. *Opened:* Omentum minus. *Incised:* Omentum majus. Truncus coeliacus arises from the aorta abdominalis at about the level of L I.

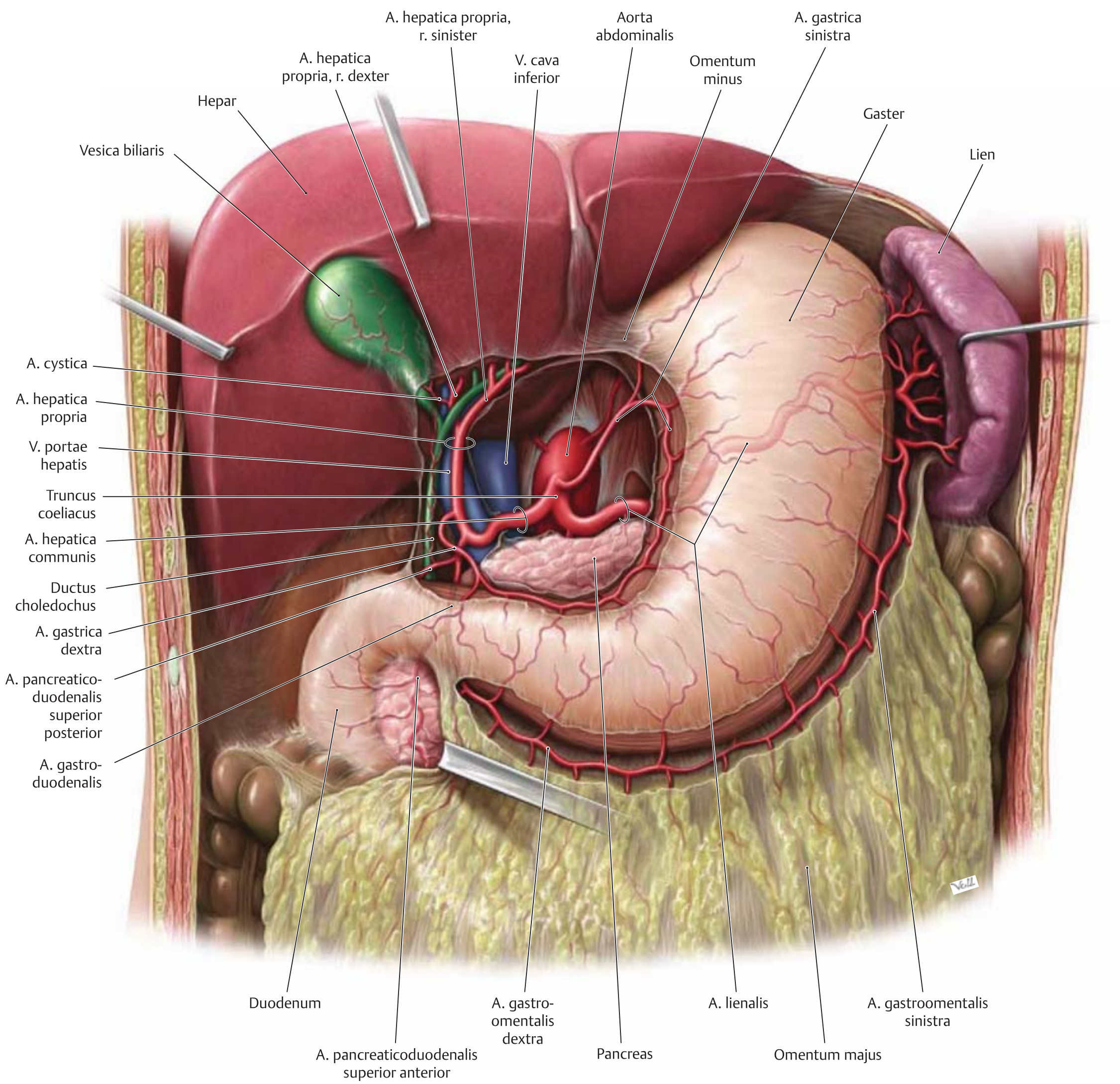
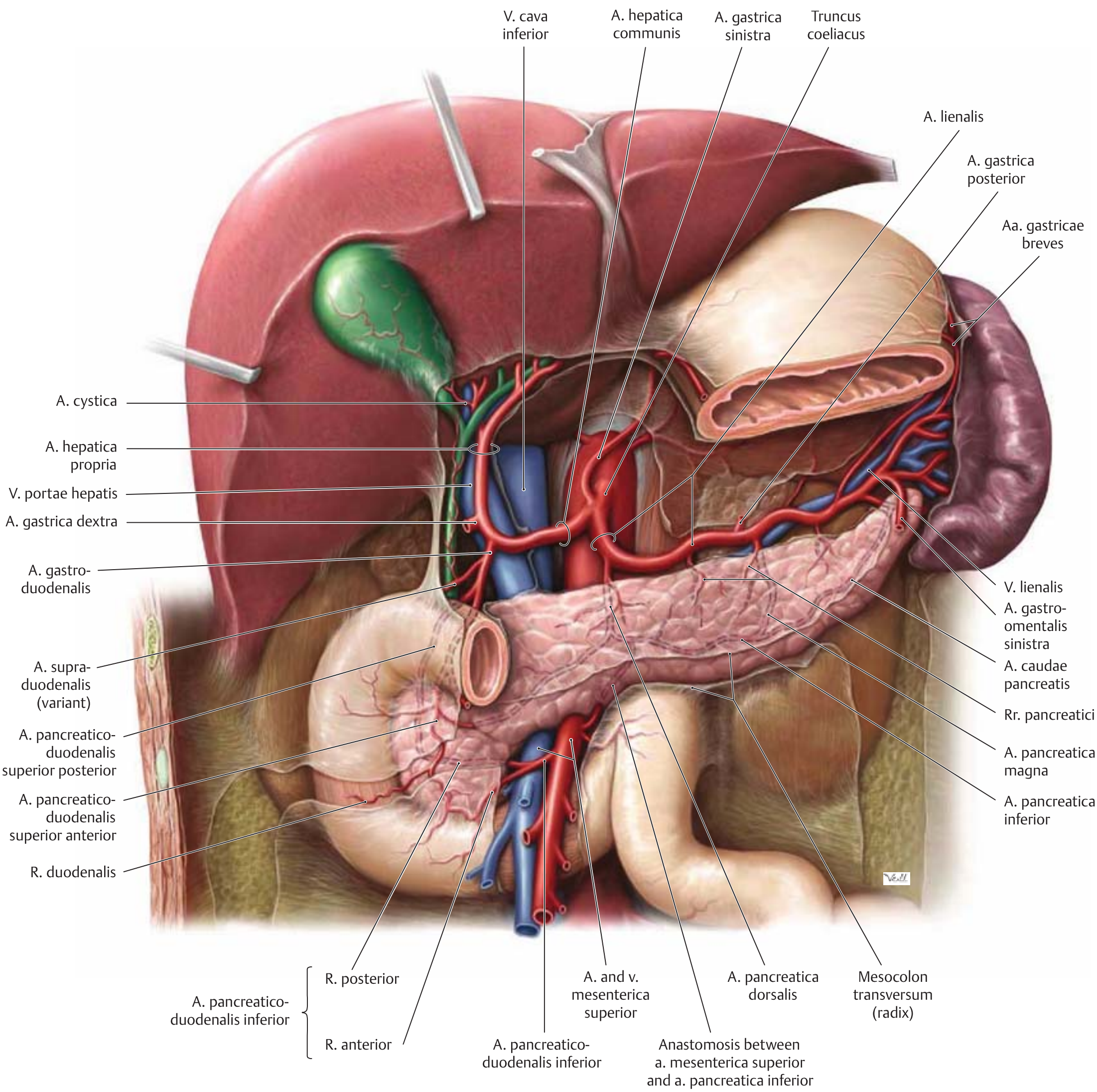


Fig. 15.9 **Truncus coeliacus: Pancreas, duodenum, and lien**
Anterior view. *Removed:* Gaster (body) and omentum minus.



Arteriae Mesenterica Superior & Inferior

Fig. 15.10 **A. mesenterica superior**
Anterior view. *Partially removed:* Gaster and peritoneum.
Note: A. colica media has been truncated (see Fig. 15.11). Aa. mesenterica superior and inferior arise from the aorta opposite L II and L III, respectively.

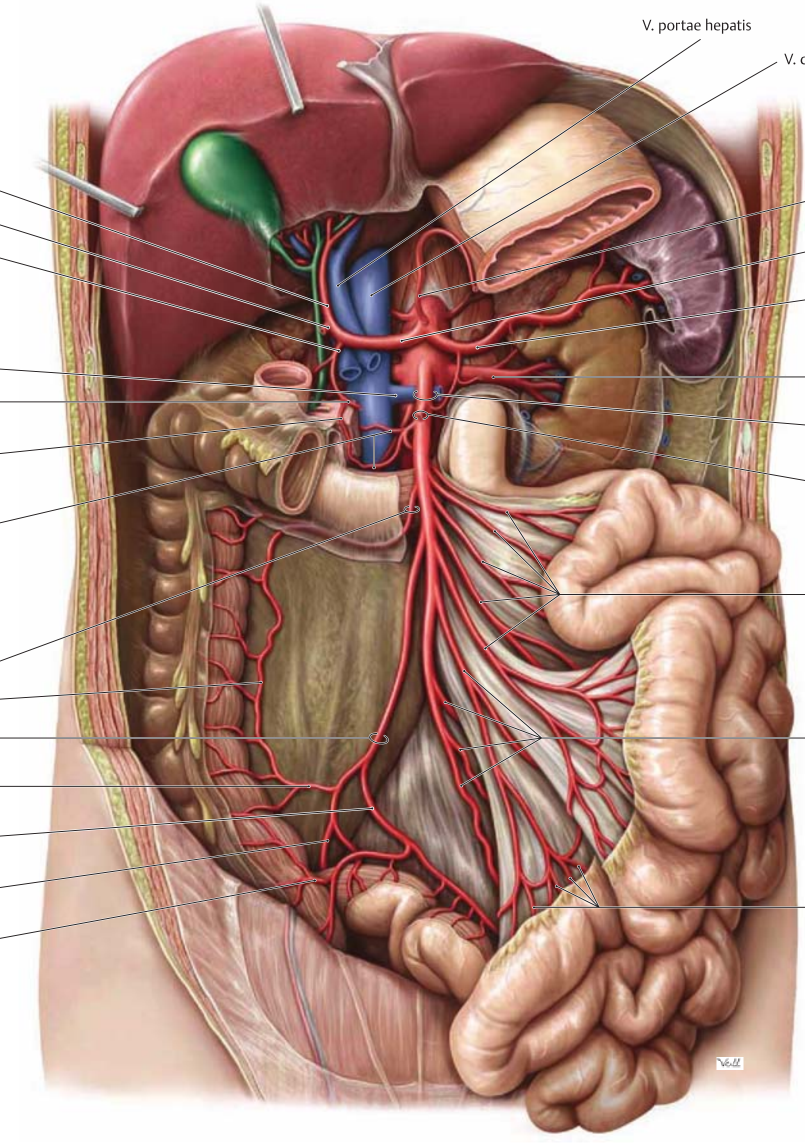
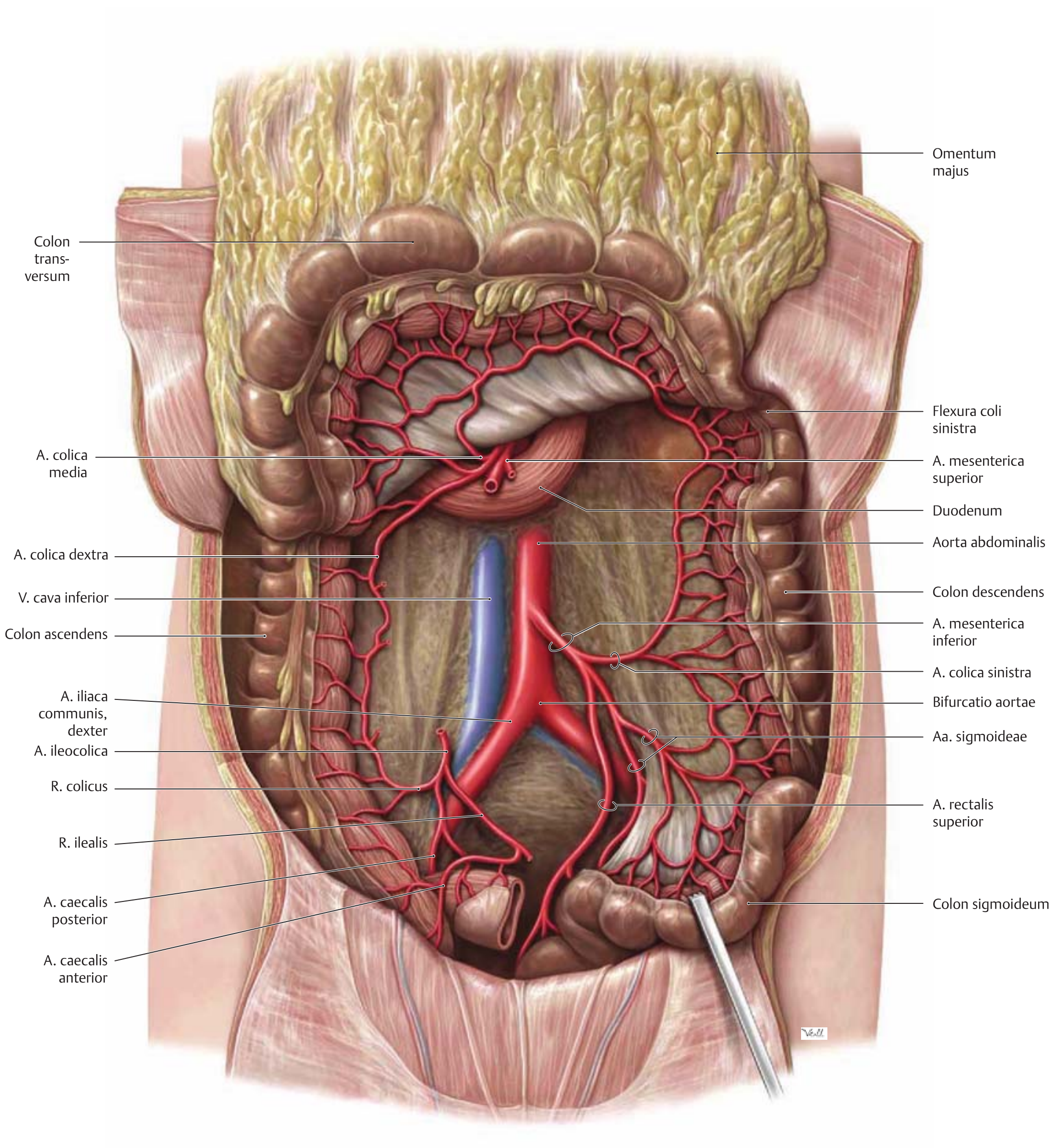


Fig. 15.11 **A. mesenterica inferior**
Anterior view. *Removed:* Jejunum and ileum. *Reflected:* Colon transversum.



Veins of the Abdomen

Fig. 15.12 **V. cava inferior: Location**
Anterior view.

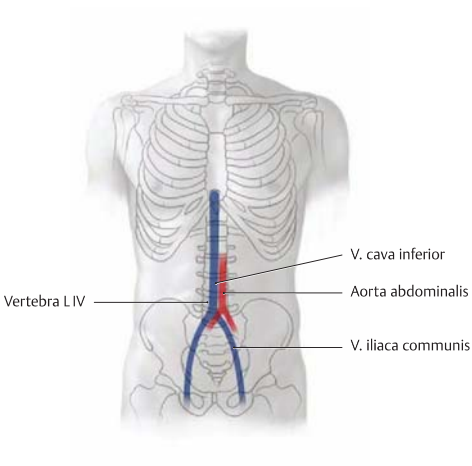
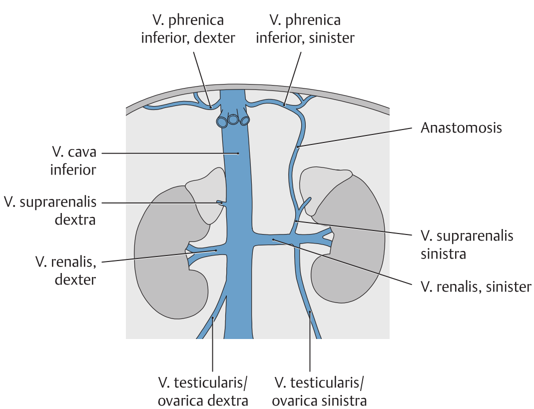


Fig. 15.13 **Tributaries of the vv. renales**
Anterior view.



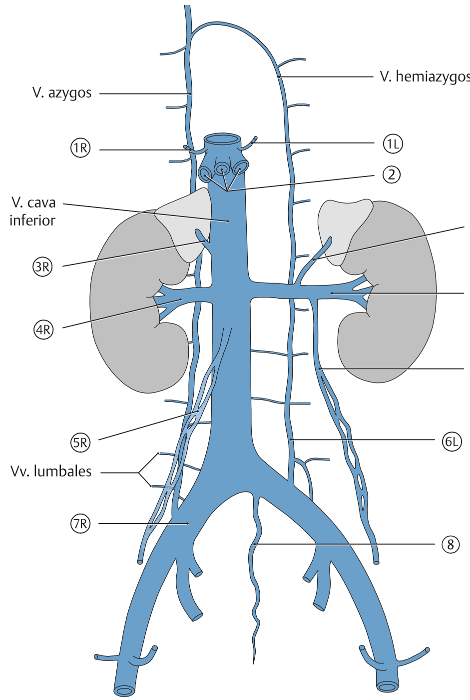
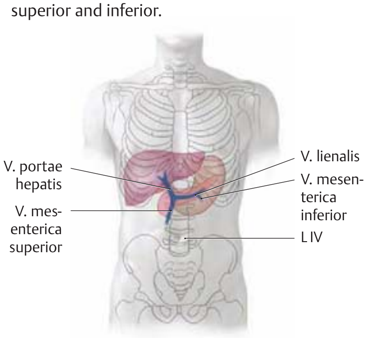


Table 15.2 **Tributaries of the inferior vena cava**

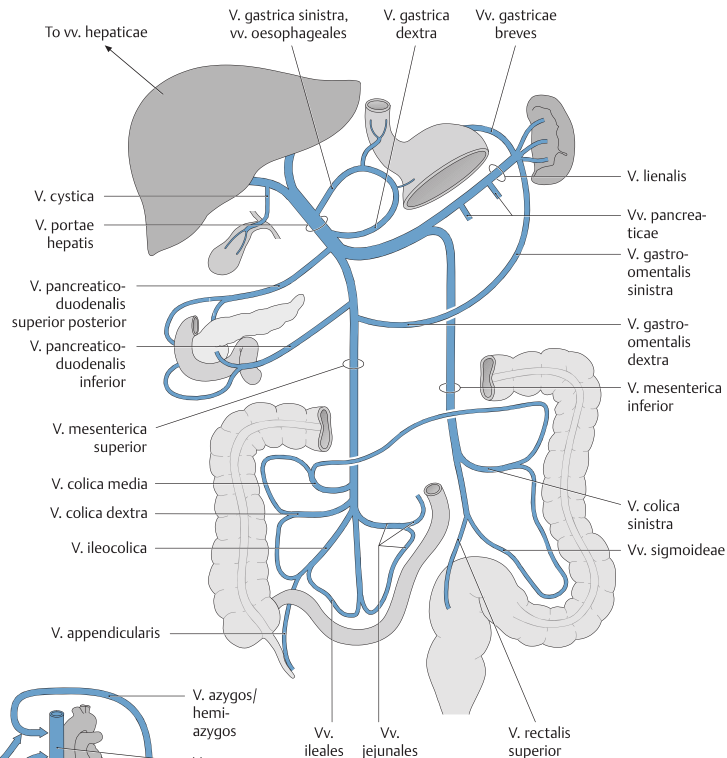
1R	1L	Vv. phrenicae inferiores (paired)
2		Vv. hepaticae (3)
3R	3L	Vv. suprarenales (the right vena is a direct tributary)
4R	4L	Vv. renales (paired)
5R	5L	Vv. testicularis/ovarica (the right vena is a direct tributary)
6R	6L	Vv. lumbales ascendens (paired)
7R	7L	Vv. iliacae communes (paired)
8		V. sacralis mediana

***Fig. 15.14* V. portae hepatis**

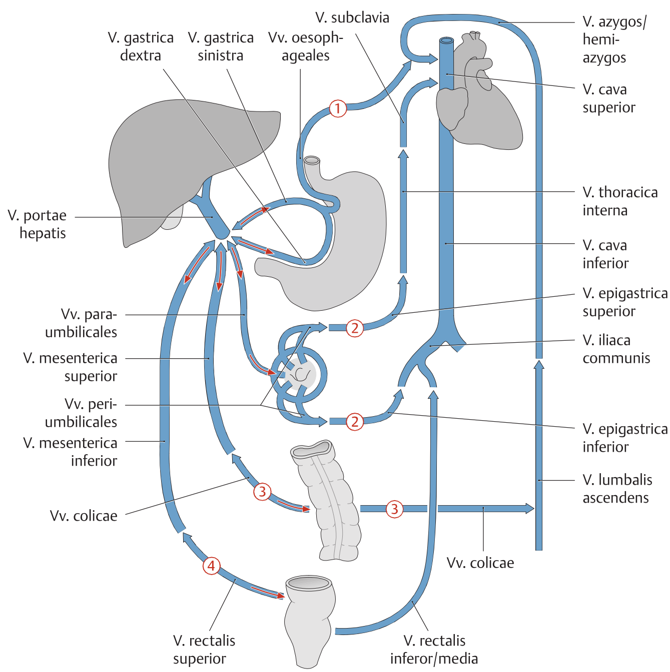
V. portae hepatis (see p. 218) drains venous blood from the abdominopelvic organs supplied by truncus coeliacus and aa. mesenterica superior and inferior.



A Location, anterior view.



B V. portae distribution.



C Collateral pathways (portosystemic collaterals). When the portal system is compromised, nutrient-laden blood may be transported to the heart via the venae cavae without passing through hepar. Red arrows indicate flow reversal.

Clinical

Cancer metastases

Tumors in the region drained by v. rectalis superior may spread through the portal venous system to the capillary bed of hepar (hepatic metastasis). Tumors drained by vv. rectalis media and inferior may metastasize to the capillary bed of the lung (pulmonary metastasis) via the v. cava inferior and right heart.

Vena Cava Inferior & Venae Renales

Fig. 15.15 Vena cava inferior
Anterior view of the female abdomen. *Removed:* All organs (except ren and gl. suprarenalis sinister).

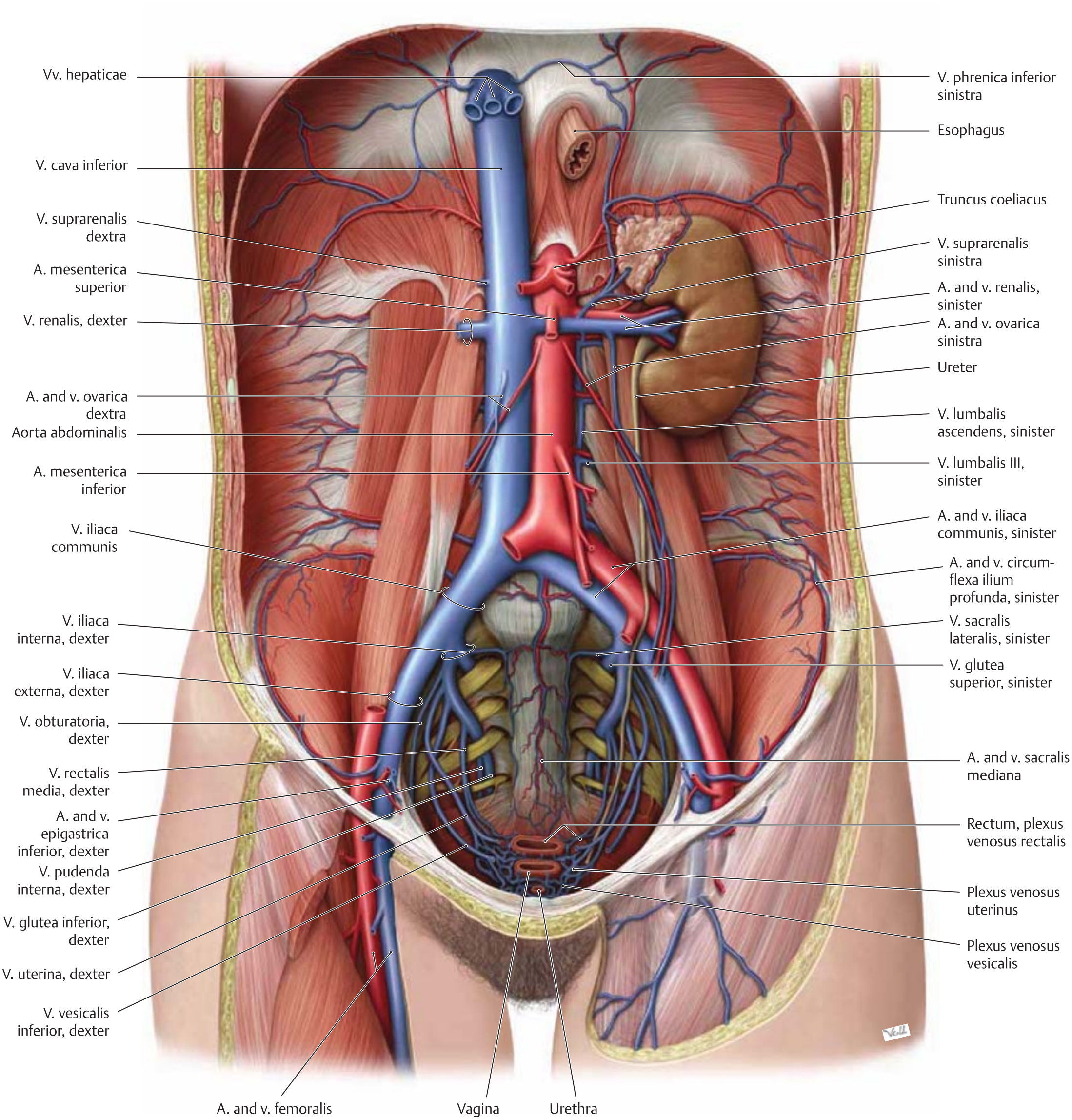
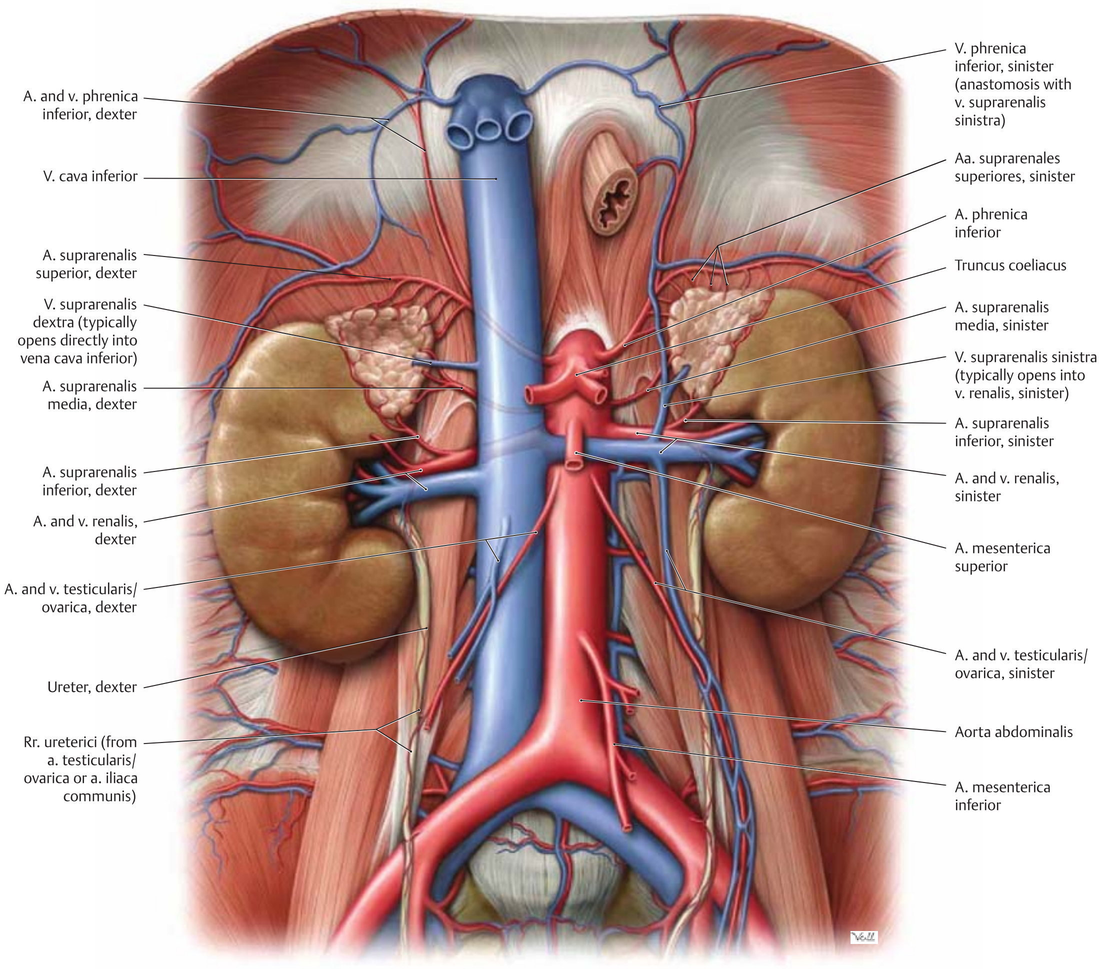


Fig. 15.16 **Vv. renales**
Anterior view. See p. 209 for aa. renales in isolation.



Vena Portae Hepatis

V. portae hepatis is typically formed by the union of v. mesenterica superior and v. lienalis posterior to the neck of the pancreas. The distribution of v. portae hepatis is shown on p. 215.

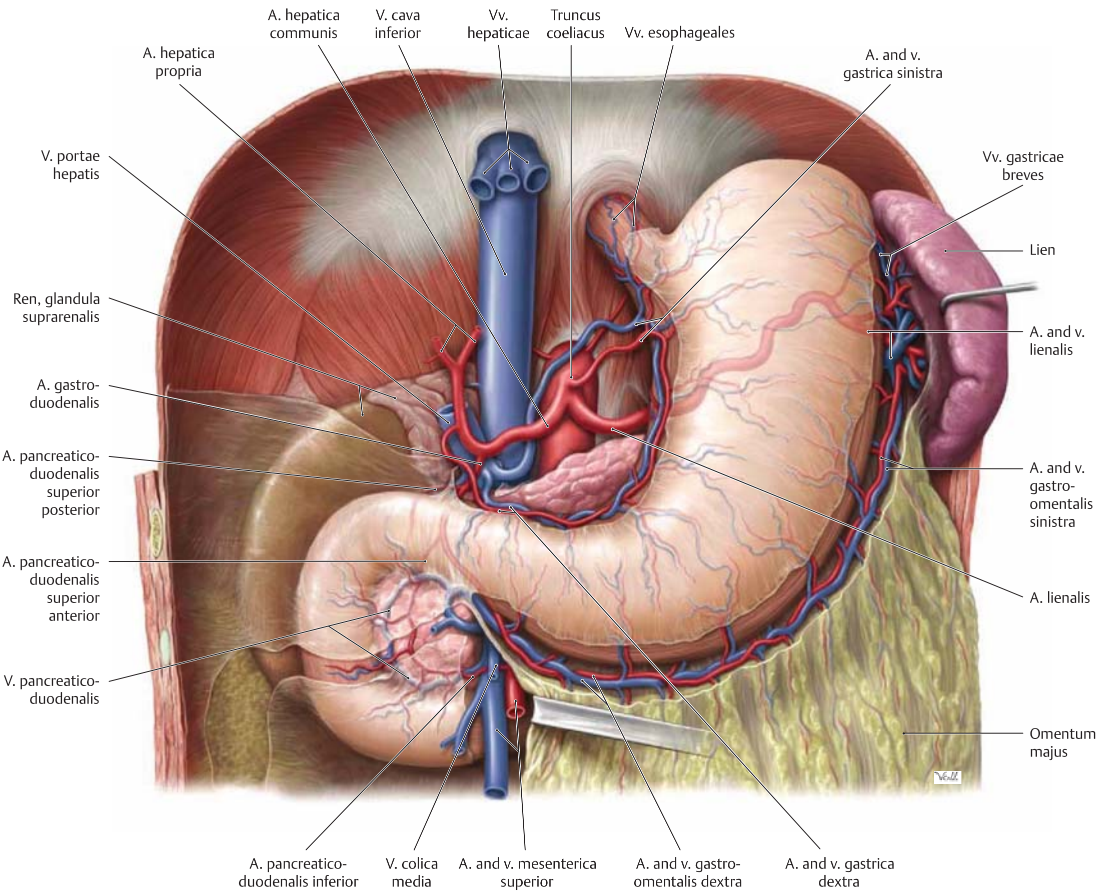
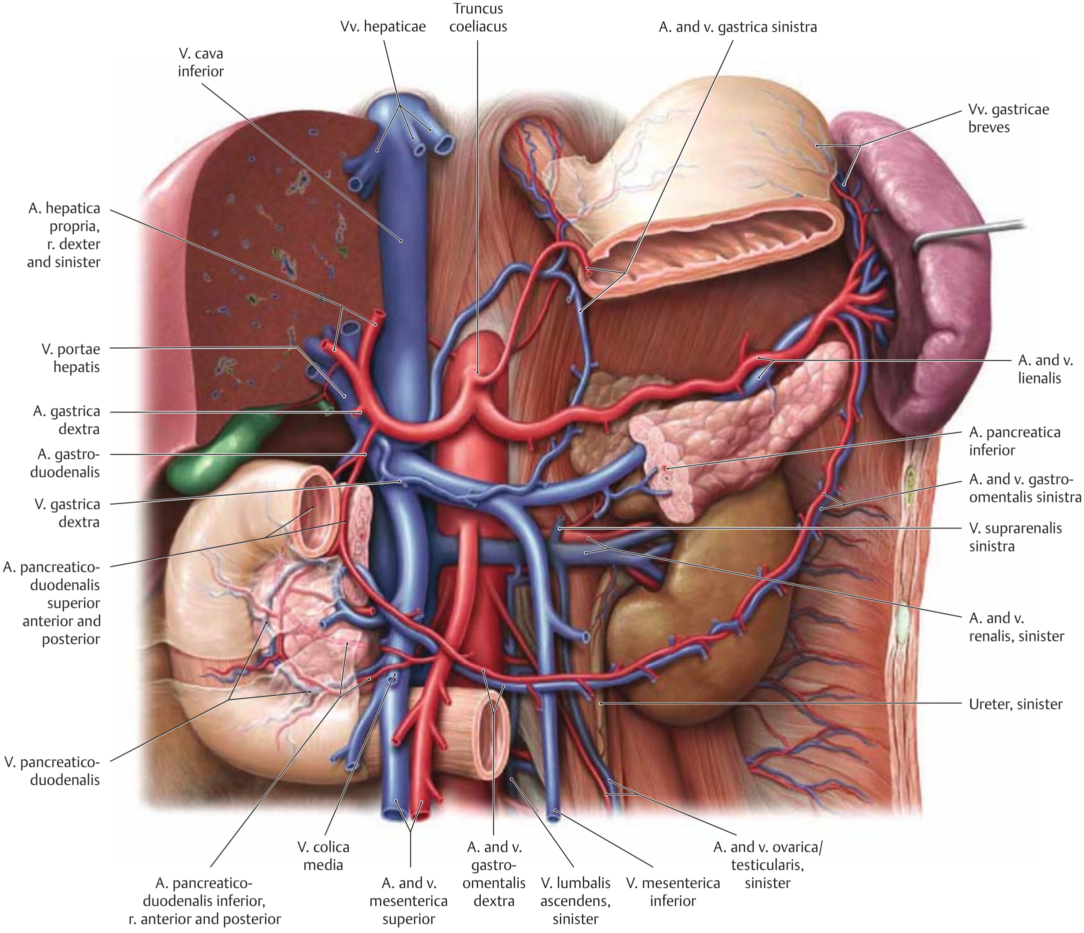


***Fig. 15.17* V. portae hepatis: Gaster and duodenum**
Anterior view. *Removed:* Hepar, omentum minus, and peritoneum. *Opened:* Omentum majus.

Fig. 15.18 **V. portae hepatis: Pancreas and lien**
Anterior view. *Partially removed:* Gaster, pancreas, and peritoneum.



Venae Mesenterica Superior & Inferior

***Fig. 15.19* V. mesenterica superior**
Anterior view. *Partially removed:* Gaster, pancreas, peritoneum, mesenterium, and colon transversum. *Displaced:* Intestinum tenue.

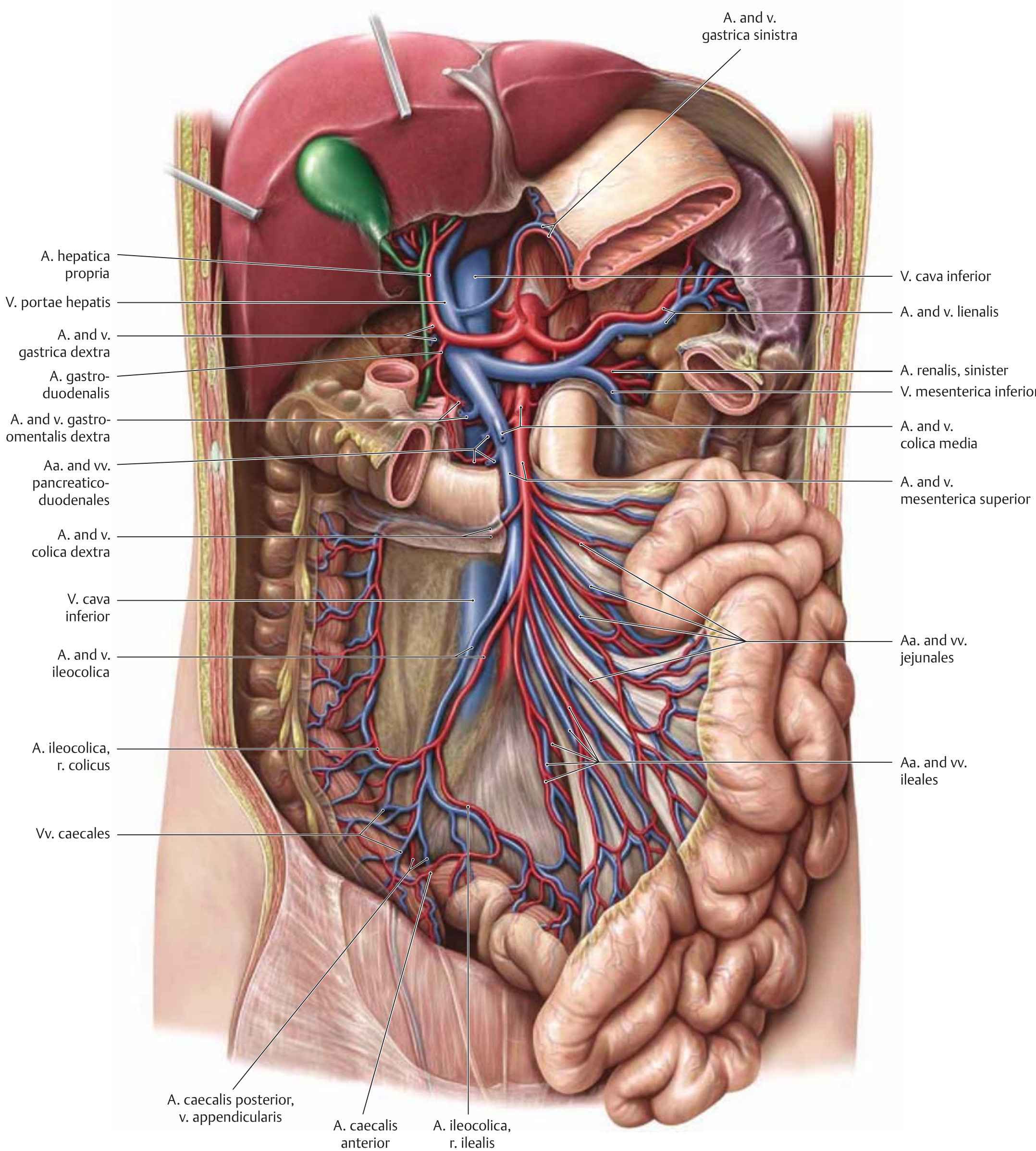
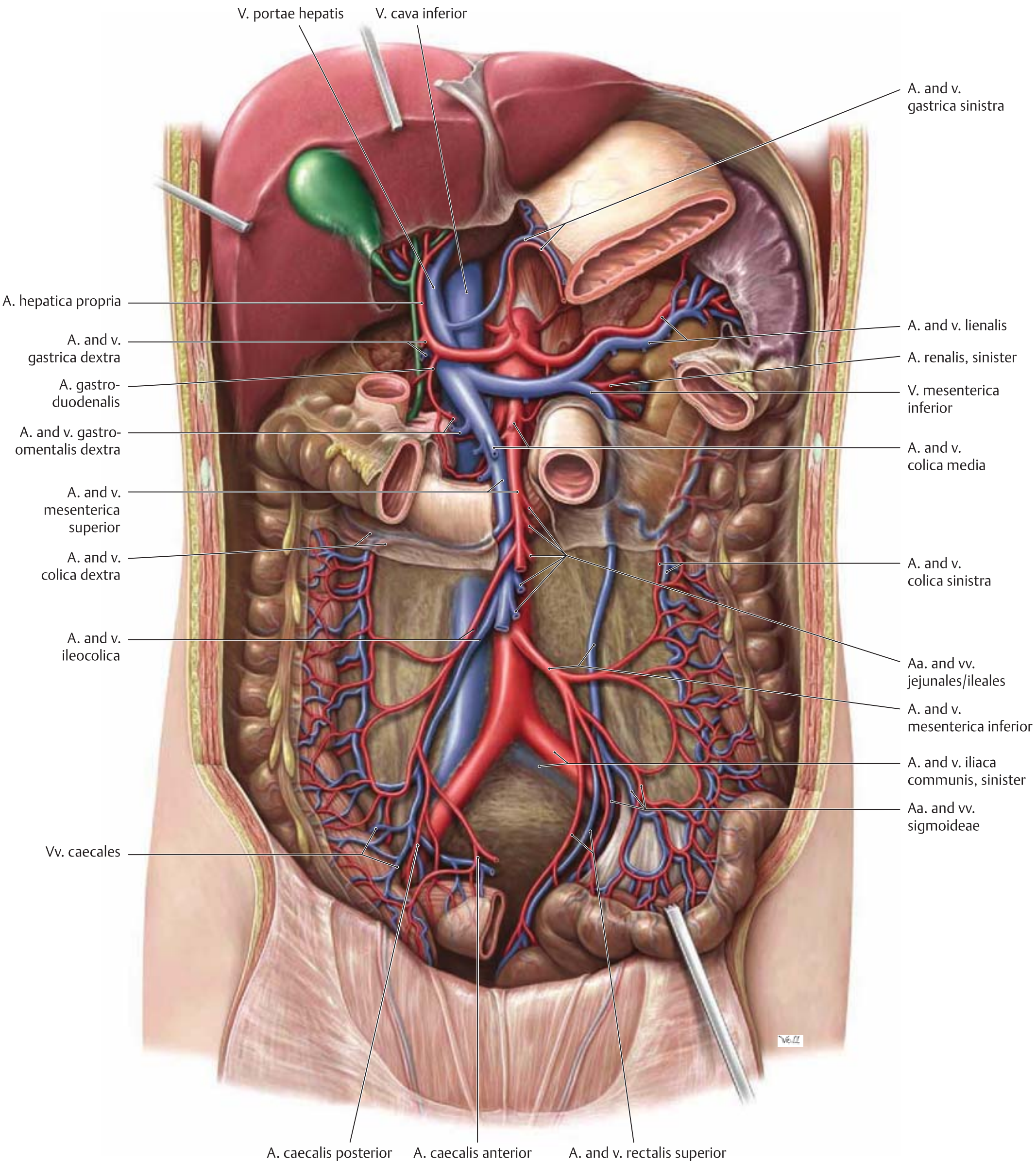
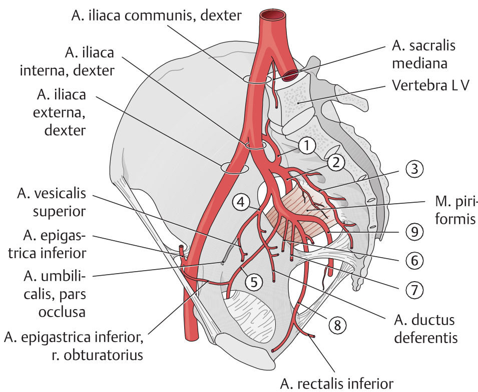


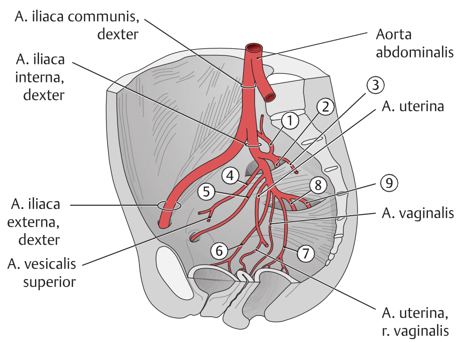
Fig. 15.20 V. mesenterica inferior
Anterior view. *Removed:* Gaster, pancreas, intestinum tenue, and peritoneum.



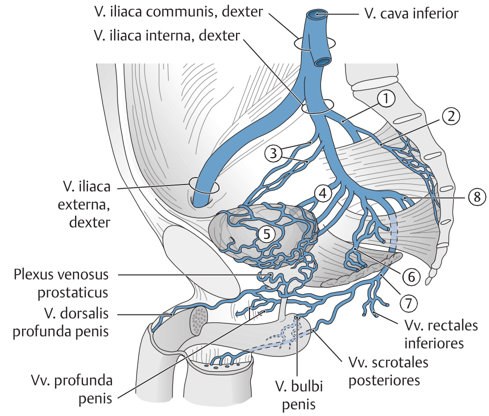
Arteries & Veins of the Pelvis



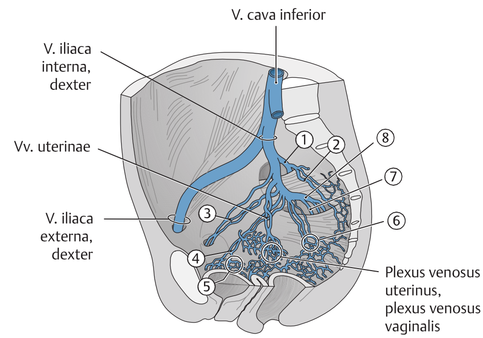
A Male pelvis.



B Female pelvis.



A Male pelvis.



B Female pelvis.

Table 15.3 Branches of the A. iliaca interna

The A. iliaca interna gives off five parietal (pelvic wall) and four visceral (pelvic organs) branches.* Parietal branches are shown in italics.

Branches		
①	*A. iliolumbalis*	
②	*A. glutea superior*	
③	*A. sacralis lateralis*	
④	A. umbilicalis	A. ductus deferentis
		A. vesicalis superior
⑤	*A. obturatoria*	
⑥	A. vesicalis inferior	
⑦	A. rectalis media	
⑧	A. pudenda interna	A. rectalis inferior
⑨	*A. glutaea inferior*	

* In the female pelvis, a. uterina and a. vaginalis may arise directly from a. iliaca interna.

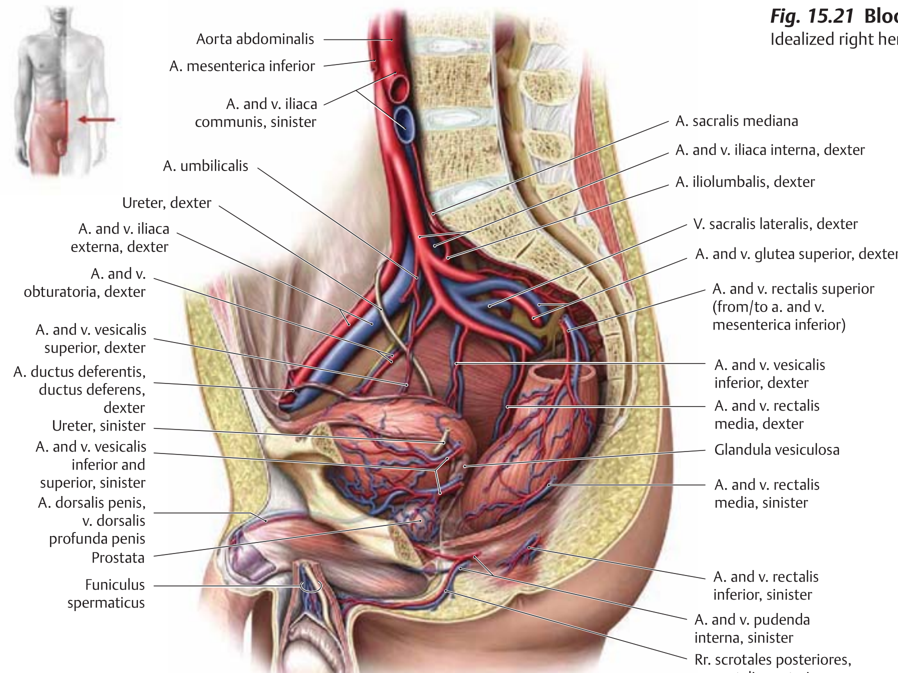
Table 15.4 Venous drainage of the pelvis

Tributaries	
①	V. glutaea superior
②	V. sacralis lateralis
③	Vv. obturatoriae
④	Vv. vesicales
⑤	Plexus venosus vesicalis
⑥	Vv. rectales mediae (plexus venosus rectalis) (also vv. rectales inferior/superior, not shown)
⑦	V. pudenda interna
⑧	Vv. glutaea inferiores

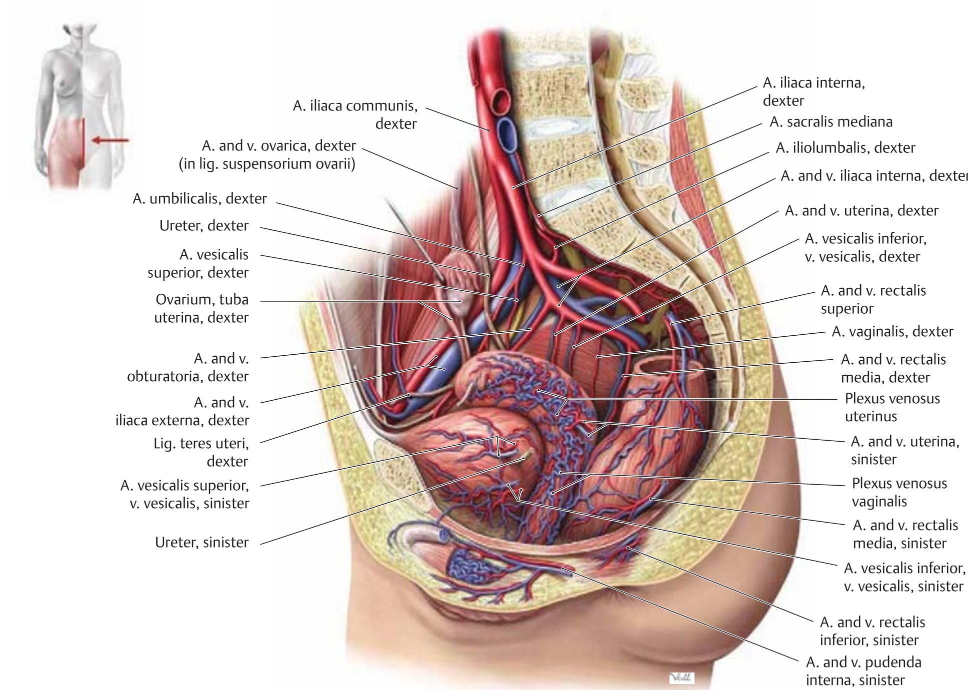
The male pelvis also contains a plexus venosus prostaticus and venae draining the penis and scrotum. The female pelvis contains vv. uterinae and plexus venosus vaginalis.

Fig. 15.21 Blood vessels of the pelvis

Idealized right hemipelvis, left lateral view.



A Male pelvis.



B Female pelvis.

Arteries & Veins of the Rectum & Genitalia

Fig. 15.22 **Blood vessels of the rectum**
Posterior view. The main blood supply to the rectum is from aa. rectales superiores; the aa. rectales mediae serve as an anastomosis between aa. rectales superior and inferior.

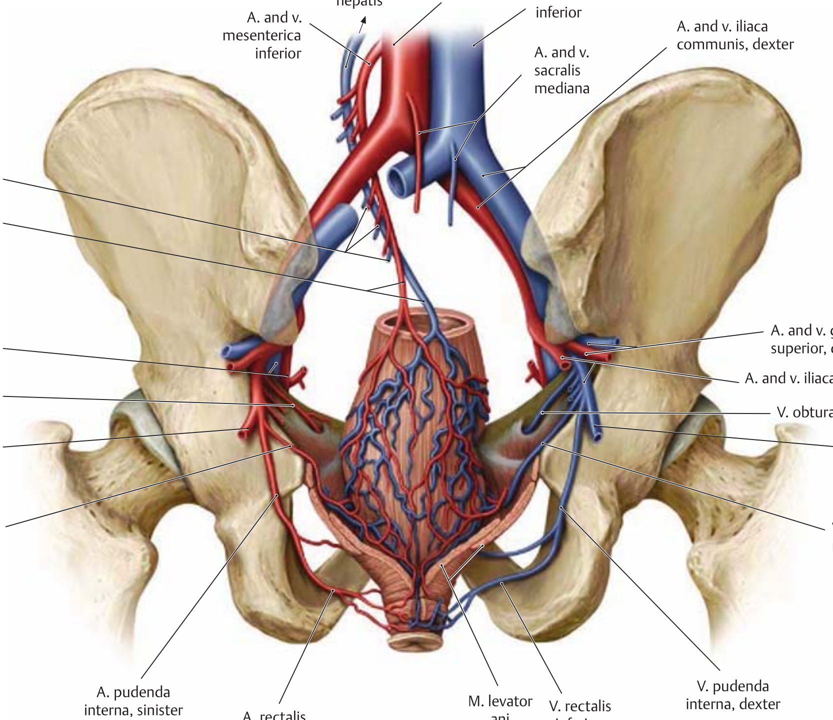
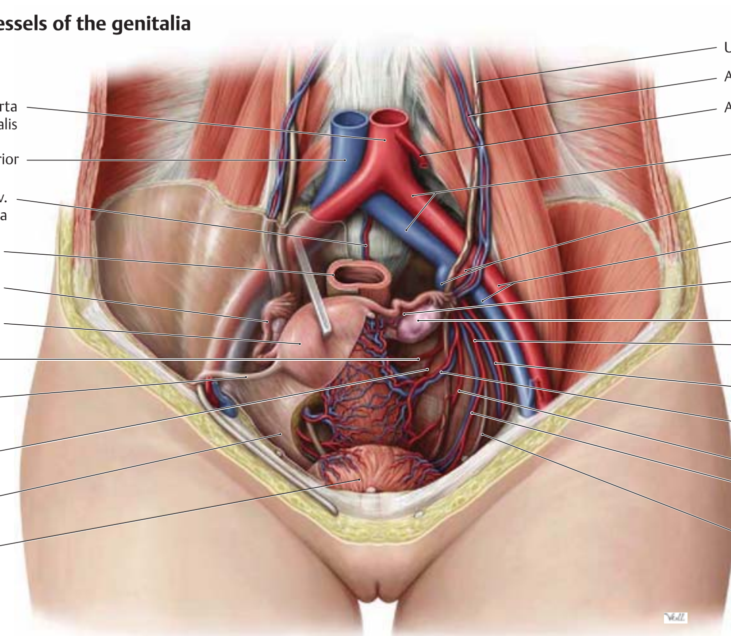
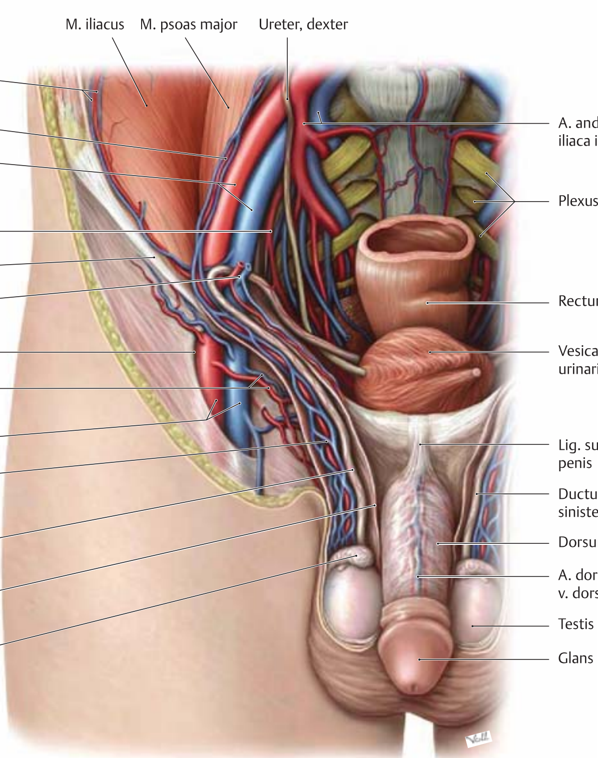


Fig. 15.23 Blood vessels of the genitalia
Anterior view.



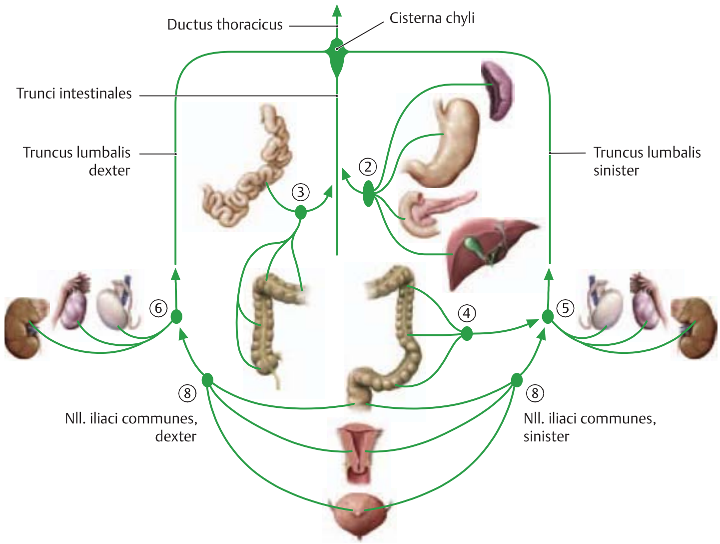
A Female pelvis. *Removed:* Peritoneum (left side). *Displaced:* Uterus.



B Male pelvis. *Opened:* Canalis inguinalis and coverings of funiculus spermaticus.

Lymph Nodes of the Abdomen & Pelvis

Fig. 16.1 **Lymphatic drainage of the internal organs**
See Table 16.1 for numbering. Lymph drainage from the abdomen, pelvis, and lower limb ultimately passes through the lumbar lymph nodes (clinically: aortic nodes). The lumbar lymph nodes consist of the right (caval) and left lateral aortic nodes, the preaortic nodes, and the retroaortic nodes. Efferent lymph vessels from the lumbar and preaortic nodes form trunci lumbales and intestinalis, respectively. Trunci lumbales and intestinalis terminate into the cisterna chyli.



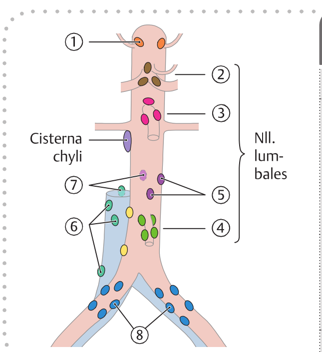


Table 16.1 Nodi lymphatici of the abdomen

① Nll. phrenici inferiores		
Nll. lumbales	Nll. preaortici	② Nll. coeliaci
		③ Nll. mesenterici superiores
		④ Nll. mesenterici inferiores
	⑤ Nll. aortici laterales sinister	
	⑥ Nll. aortici (cava) laterales dexter	
	⑦ Nll. retroaortici	
⑧ Nll. iliaci communis		

Fig. 16.2 **Lymphatic drainage of the rectum**
Anterior view.

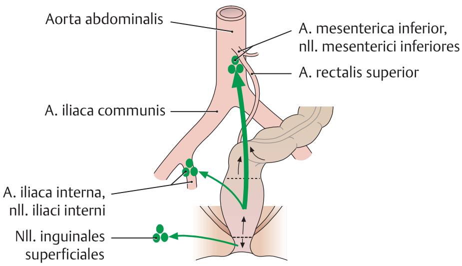


Fig. 16.3 **Lymphatic drainage of vesica urinaria and urethra**
Anterior view.

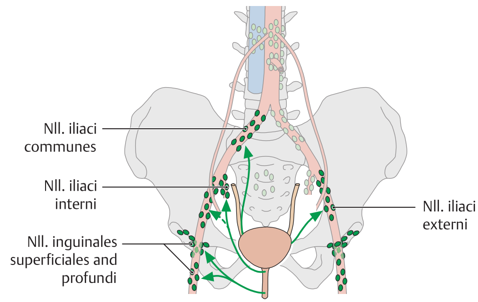


Fig. 16.4 **Lymphatic drainage of the male genitalia**
Anterior view.

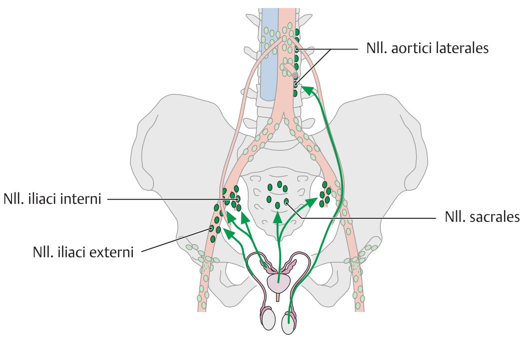
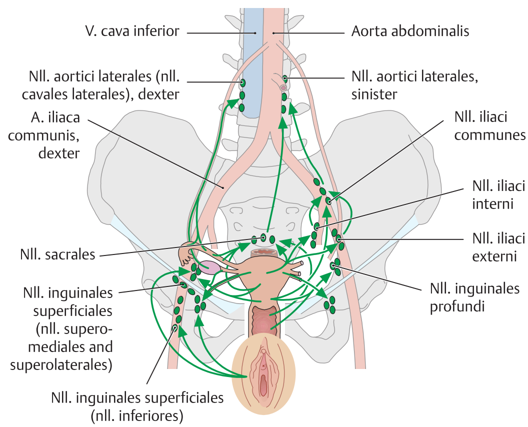


Fig. 16.5 **Lymphatic drainage of the female genitalia**
Anterior view.



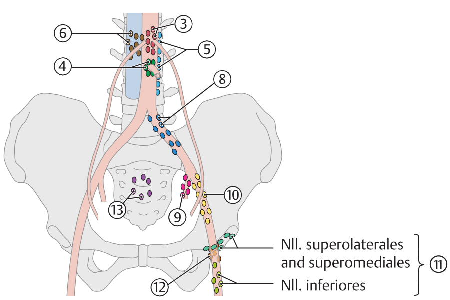


Table 16.2	**Nodi lymphatici of the pelvis**
Numbers continued from Table 16.1.	
Nll. preaortici	③ Nll. mesenterici superiores
	④ Nll. mesenterici inferiores
⑤ Nll. aortici laterales sinister	
⑥ Nll. aortici (cava) laterales dexter	
⑧ Nll. iliaci communis	
⑨ Nll. iliaci interni	
⑩ Nll. iliaci externi	
⑪ Nll. inguinales superficiales	Horizontal group
	Vertical group
⑫ Nll. inguinales profundi	
⑬ Nll. sacrales	

Lymph Nodes of the Posterior Abdominal Wall

Lymph nodes in the abdomen and pelvis may be classified as either parietal or visceral. The majority of the parietal lymph nodes are located on the posterior abdominal wall.

Fig. 16.6 **Parietal lymph nodes in the abdomen and pelvis**
Anterior view. *Removed:* All visceral structures (except vessels).

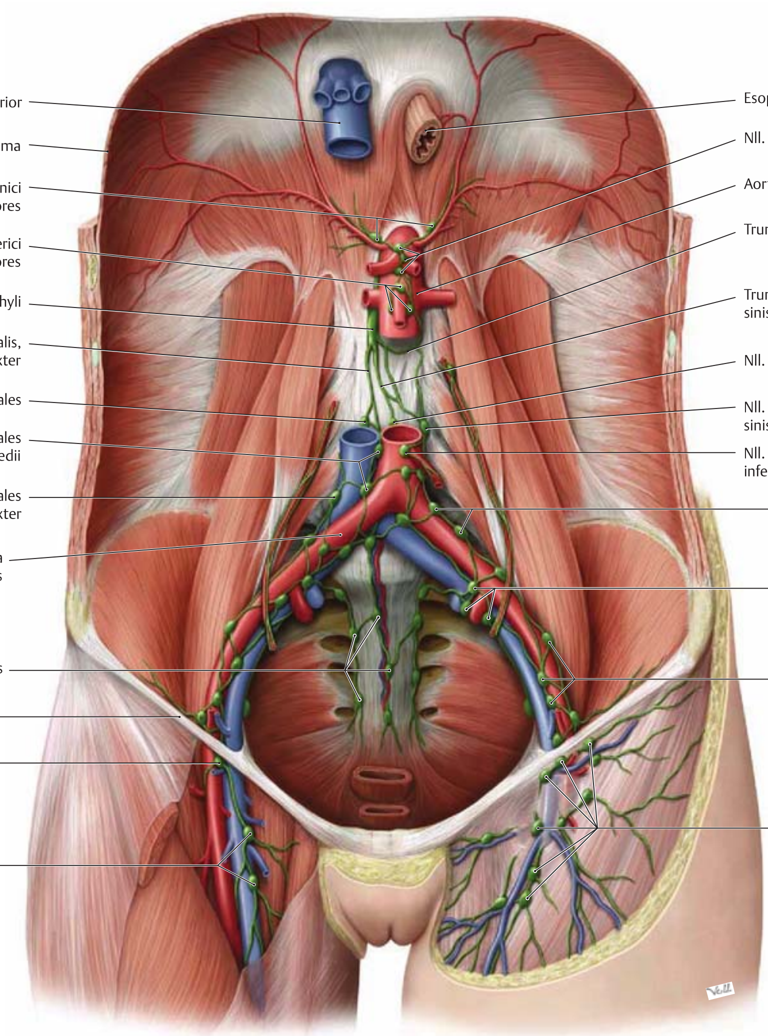


Fig. 16.7 **Lymphatic nodes of the urinary organs**
Anterior view.

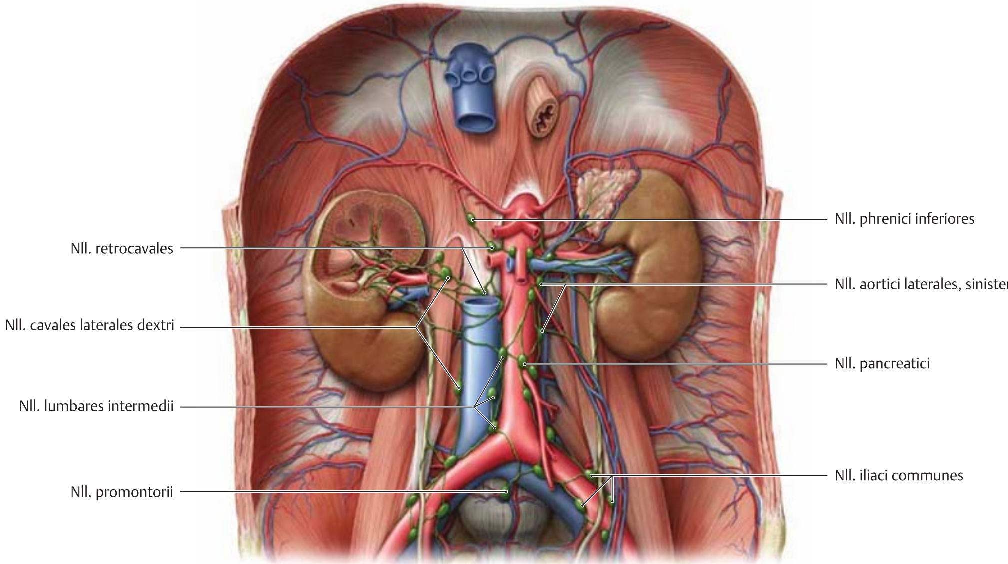


Fig. 16.8 **Drainage of renes (with pelvic organs)**

Ductus thoracicus

↑

Truncus lumbalis, dexter → **Cisterna chyli** ← **Truncus lumbalis, dexter**

↑

Nll. lumbales intermedii

↑

Nll. iliaci communes

- Nll. subaortici
- Nll. promontorii
- Nll. iliaci communes, nll. laterales and mediales and intermedii

Left column:

Nll. iliaci communes → Nll. lumbales dextri → Truncus lumbalis, dexter

- Nll. cavales laterales
- Nll. precavales
- Nll. retrocavales

Nll. lacunares (medialis and intermedius and lateralis) → Nll. iliaci externi → Nll. iliaci communes

↑

Nll. inguinales profundi

↑

Nll. inguinales superficiales

↑

Membri inferioris, uterus and vagina

Nll. iliaci externi

- Nll. obturatorii
- Nll. iliaci externi, nll. laterales and mediales and intermedii
- Nll. interiliaci

Right column:

Nll. iliaci communes → Nll. lumbales sinistri → Truncus lumbalis, dexter

- Nll. aortici laterales
- Nll. preaortici
- Nll. retroaortici

Nll. iliaca interni → Nll. iliaci communes

- Nll. sacrales
- Nll. gluteales, nll. superiores and inferiores

Lymph Nodes of the Anterior Abdominal Organs

Fig. 16.9 **Lymph nodes of gaster and hepar**
Anterior view. *Removed:* Omentum minus. *Opened:* Omentum majus.
Arrows show direction of lymphatic drainage.

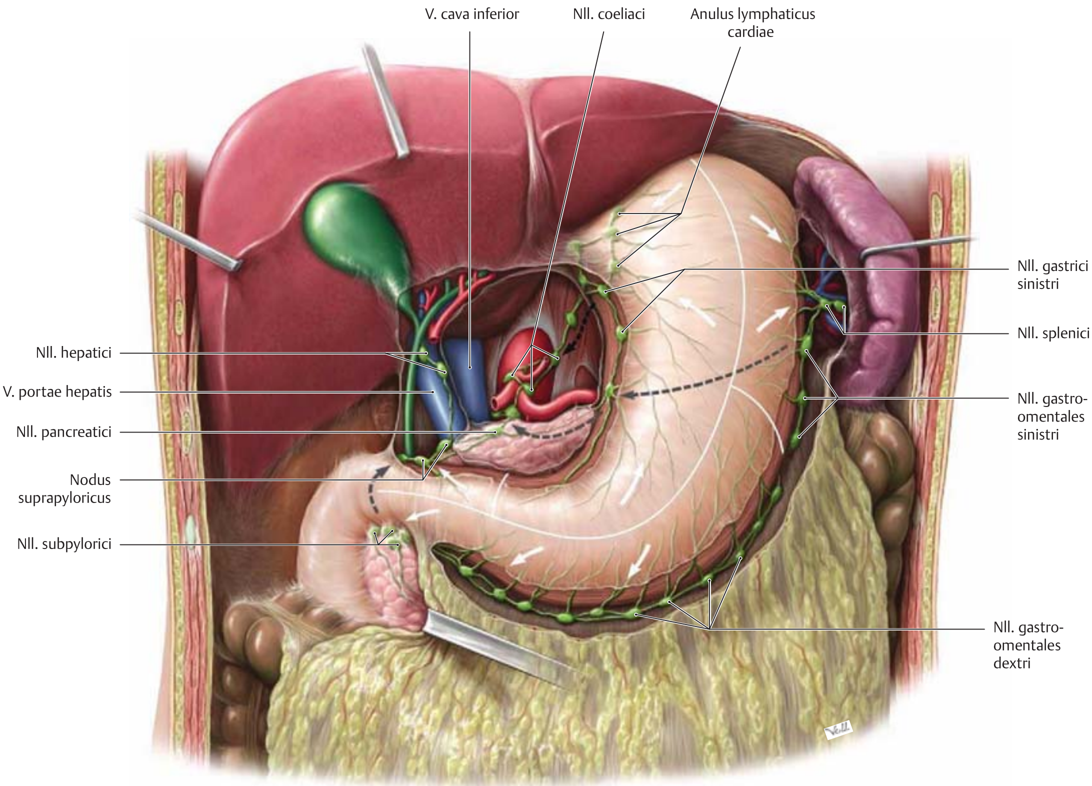


Fig. 16.10 **Lymph nodes of lien, pancreas, and duodenum**
Anterior view. *Removed:* Gaster and colon.

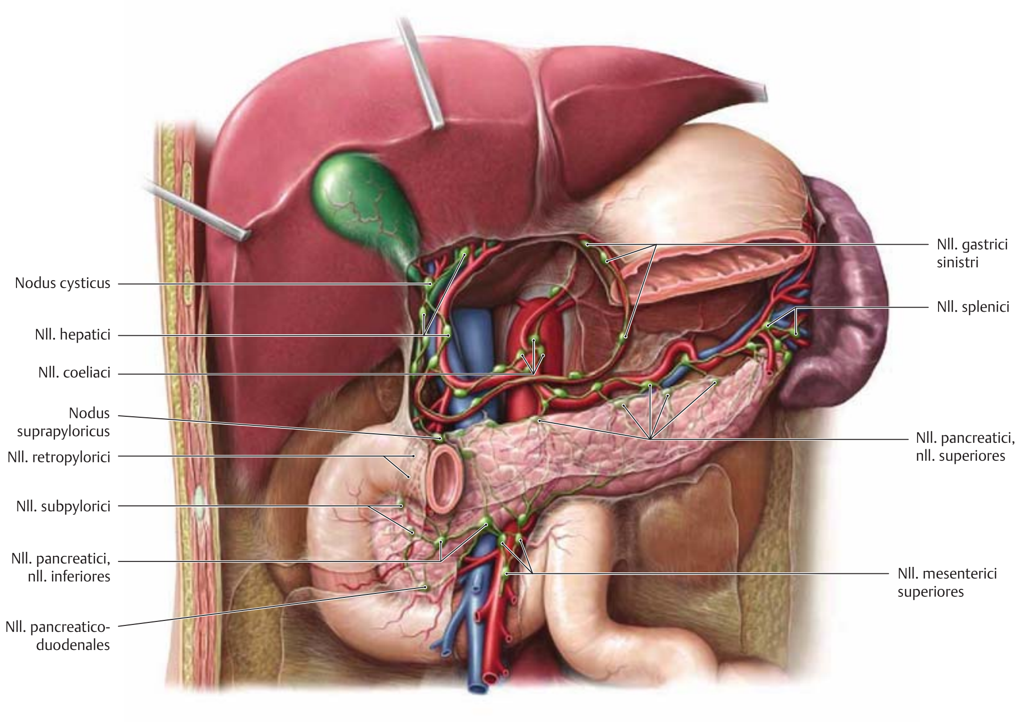
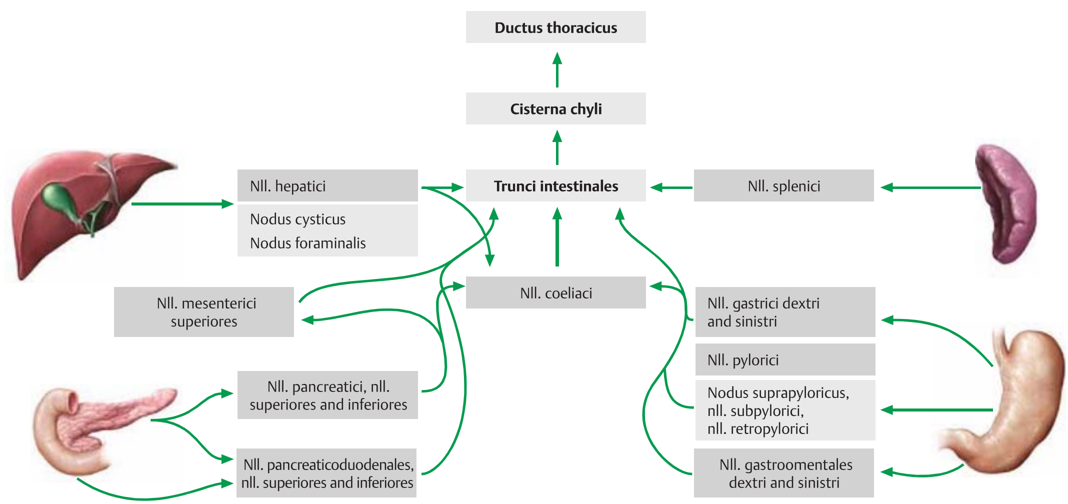


Fig. 16.11 **Lymphatic drainage of gaster, hepar, lien, pancreas, and duodenum**



Lymph Nodes of the Intestines

Fig. 16.12 **Lymph nodes of the jejunum and ileum**
Anterior view. *Removed:* Gaster, hepar, pancreas, and colon.

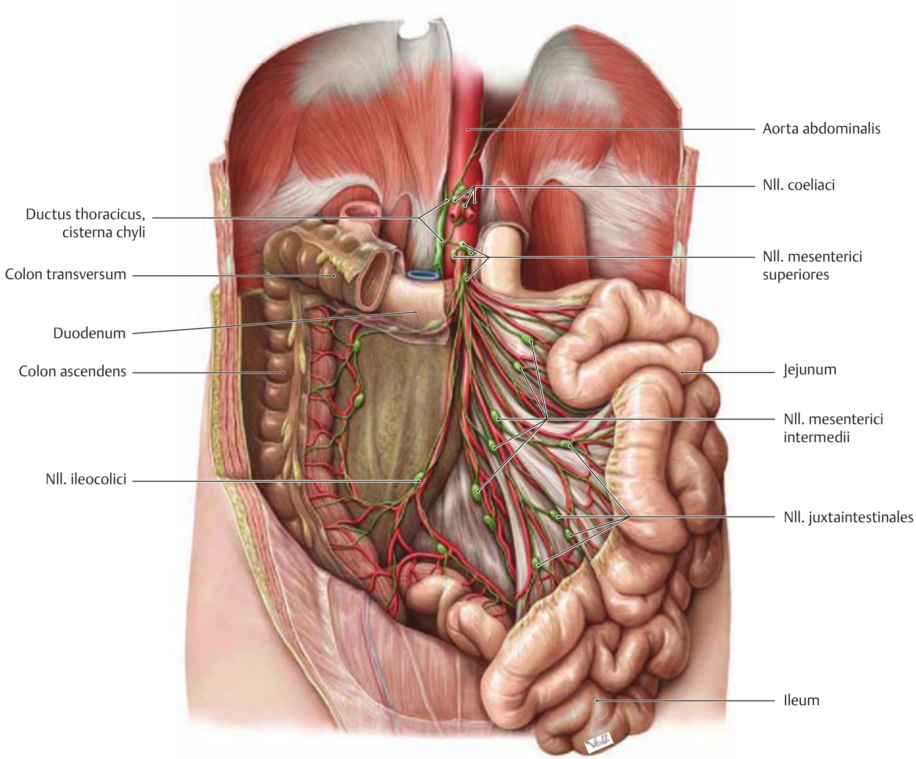


Fig. 16.13 **Lymphatic drainage of the intestines**

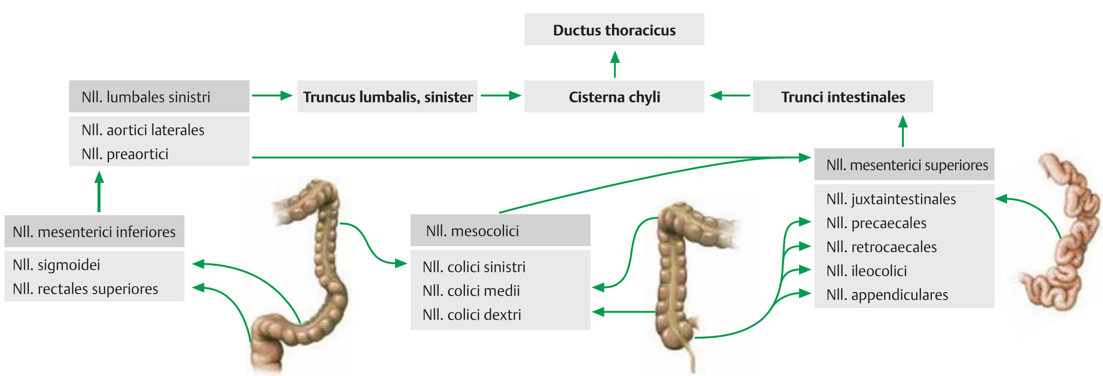
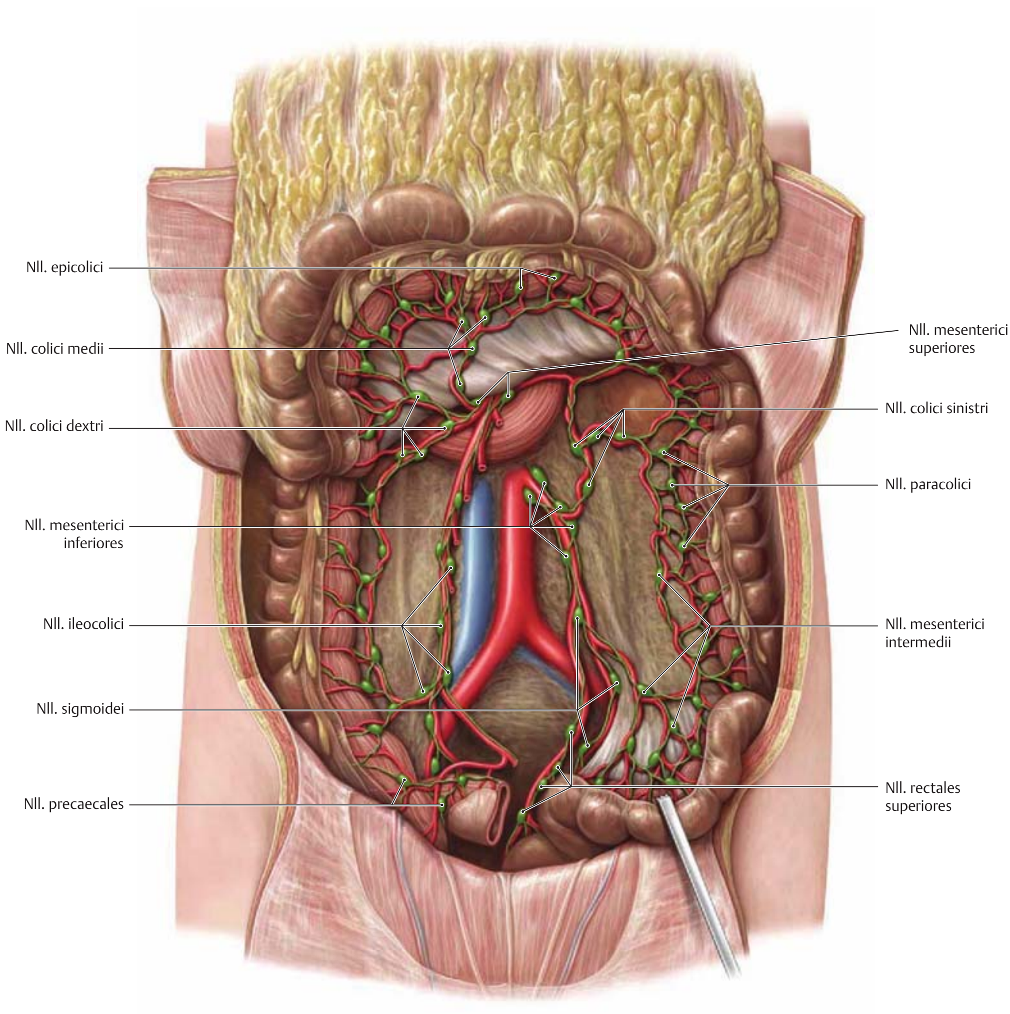


Fig. 16.14 **Lymph nodes of intestinum crassum**
Anterior view. *Reflected:* Colon transversum and omentum majus.



Lymph Nodes of the Genitalia

Fig. 16.15 **Lymph nodes of the male genitalia**
Anterior view. *Removed:* Gastrointestinal tract (except rectal stump) and peritoneum.

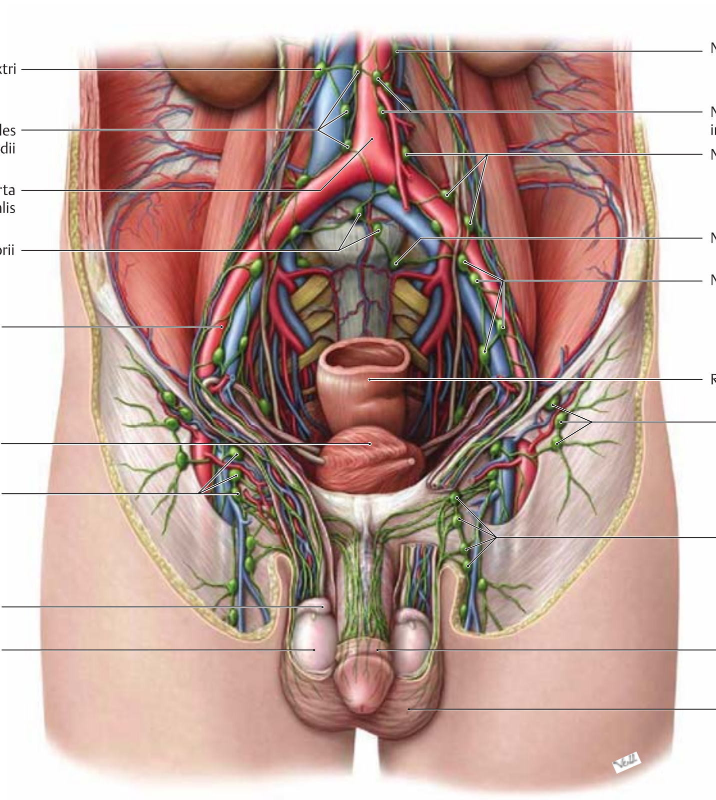


Fig. 16.16 **Lymph nodes of the female genitalia**
Anterior view. *Removed:* Gastrointestinal tract (except rectal stump) and peritoneum. *Retracted:* Uterus.

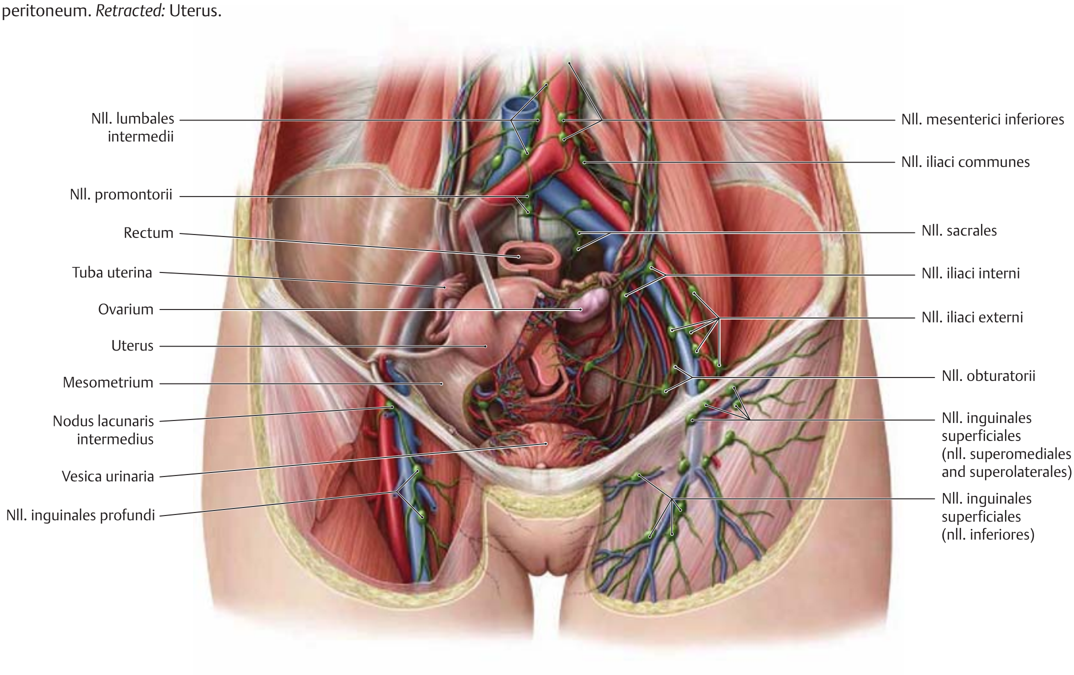
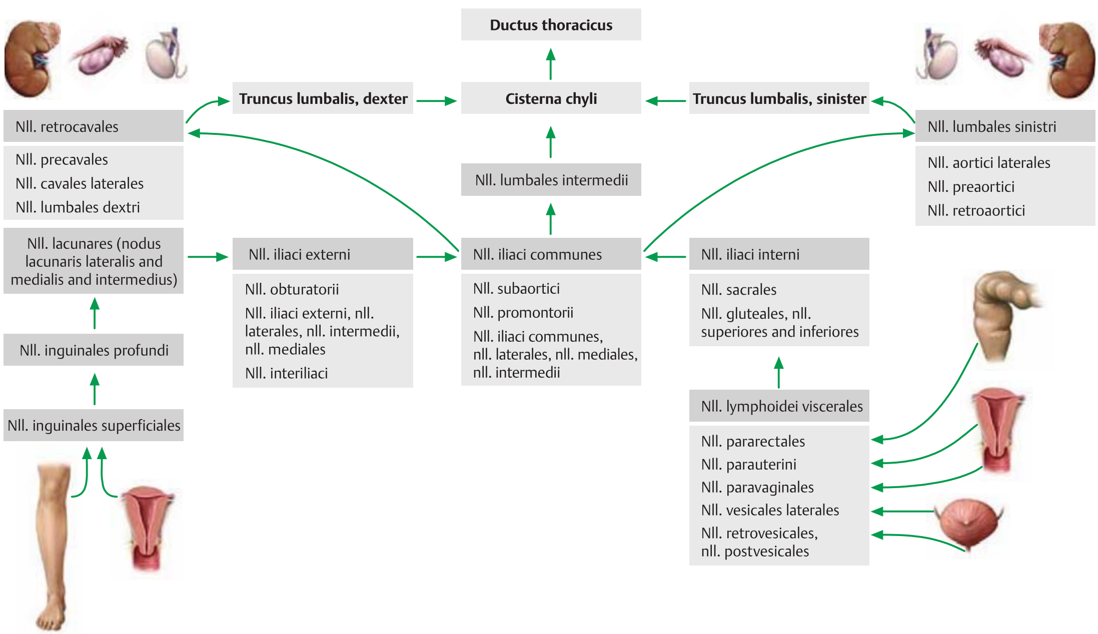


Fig. 16.17 **Lymphatic drainage of the pelvic organs**



Plexus Autonomicus

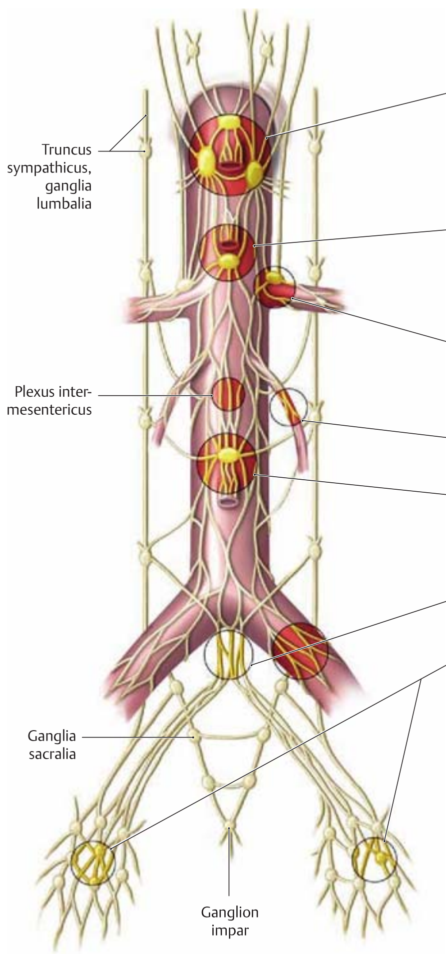
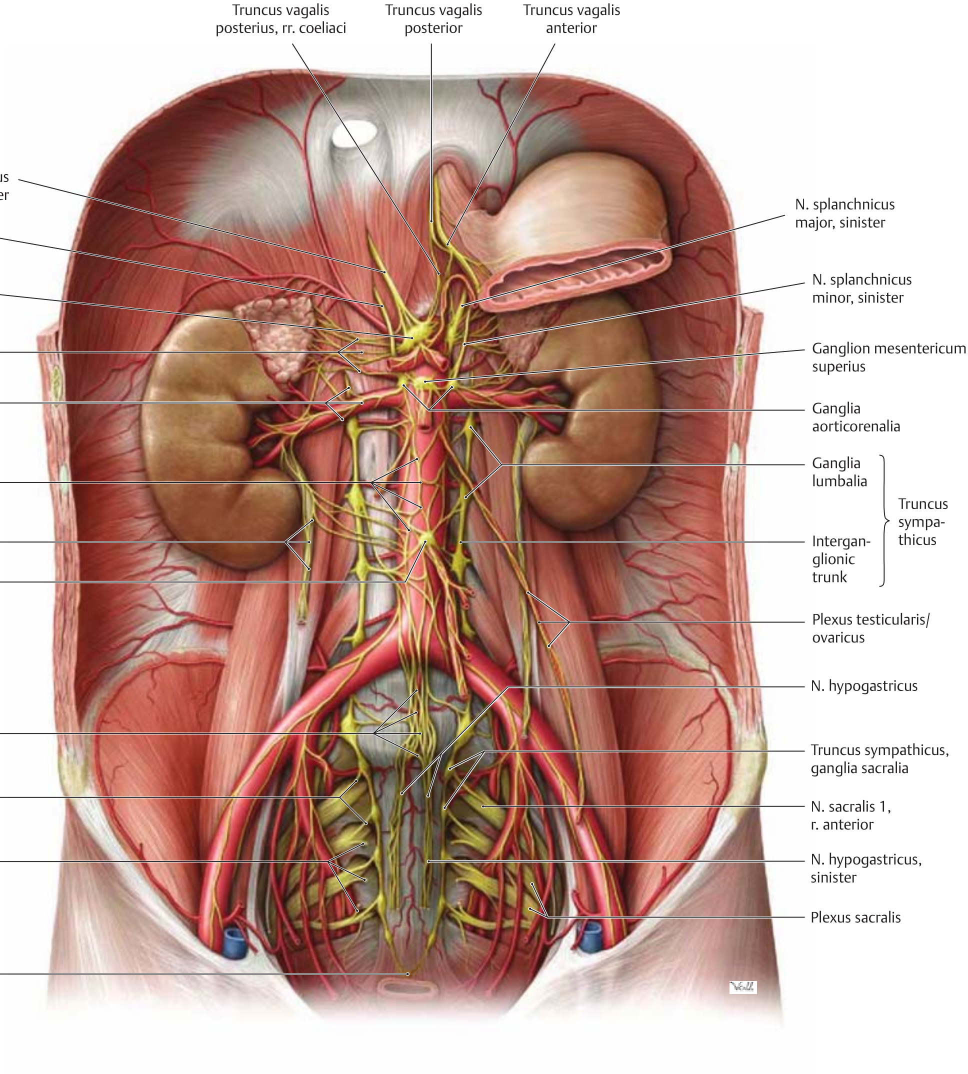


Table 17.1 Autonomic plexa in the abdomen and pelvis

Ganglia	Subplexus	Distribution
Plexus coeliacus		
Ganglion coeliacum	Plexus hepaticus	• Hepar, vesica biliaris
	Plexus gastricus	• Gaster
	Plexus splenicus	• Lien
	Plexus pancreaticus	• Pancreas
Plexus mesentericus superior		
Ganglion mesentericum superius	—	• Pancreas (caput) • Duodenum • Jejunum • Ileum • Caecum • Colon (to flexura coli sinistra) • Ovarium
Plexus suprarenalis and renalis		
Ganglia aorticorenalia	Plexus uretericus	• Glandula suprarenalis • Ren • Ureter proximalis
Plexus ovaricus/testicularis		
—	—	• Ovarium/Testis
Plexus mesentericus inferior		
—	Plexus colica sinister	• Flexura coli sinistra
	Plexus rectalis superior	• Colon descendens and sigmoideum • Upper rectum
Plexus hypogastricus superior		
—	Nn. hypogastrici	• Viscera pelvis
Plexus hypogastricus inferior		
Ganglion pelvicum	Plexus rectalis medius and inferior	• Middle and lower rectum
	Plexus prostaticus	• Prostata • Glandula vesiculosa • Glandula bulbourethralis • Ductus ejaculatorius • Penis • Urethra
	Plexus deferentialis	• Ductus deferens • Epididymis
	Plexus uterovaginalis	• Uterus • Tuba uterina • Vagina • Ovarium
	Plexus vesicalis	• Vesica urinaria
	Plexus uretericus	• Ureter (ascending from pelvis)

Fig. 17.1 **Plexus autonomicus in the abdomen and pelvis**
Anterior view of the male abdomen. *Removed:* Peritoneum and majority of gaster.



Innervation of the Abdominal Organs

Fig. 17.2 **Innervation of the anterior abdominal organs**
Anterior view. *Removed:* Omentum minus, colon ascendens, and parts of colon transversum. *Opened:* Bursa omentalis. Trunci vagalis anterior and posterior each produce a r. coeliacus, r. hepaticus and r. pyloricus, and a plexus gastricus. See p. 245 for schematic.

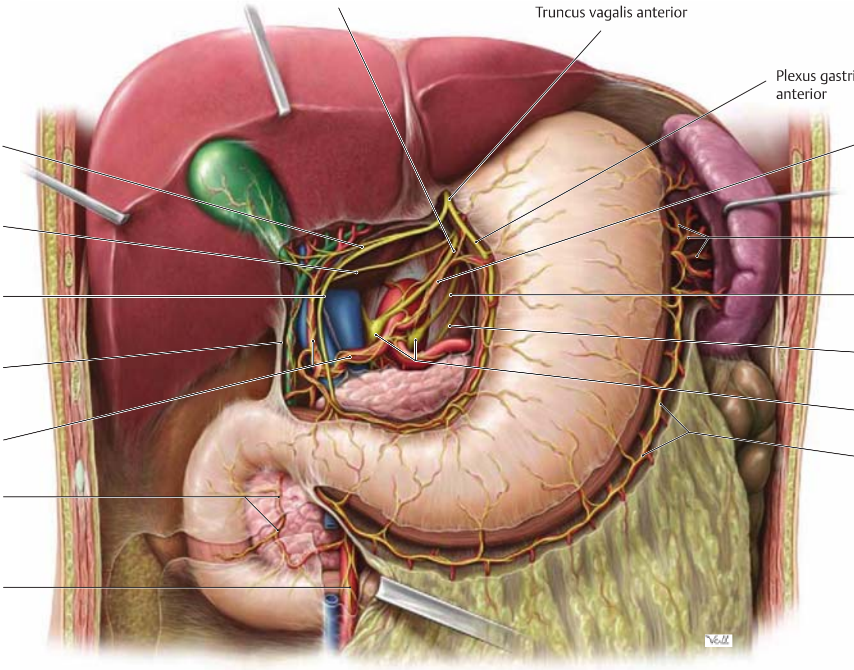
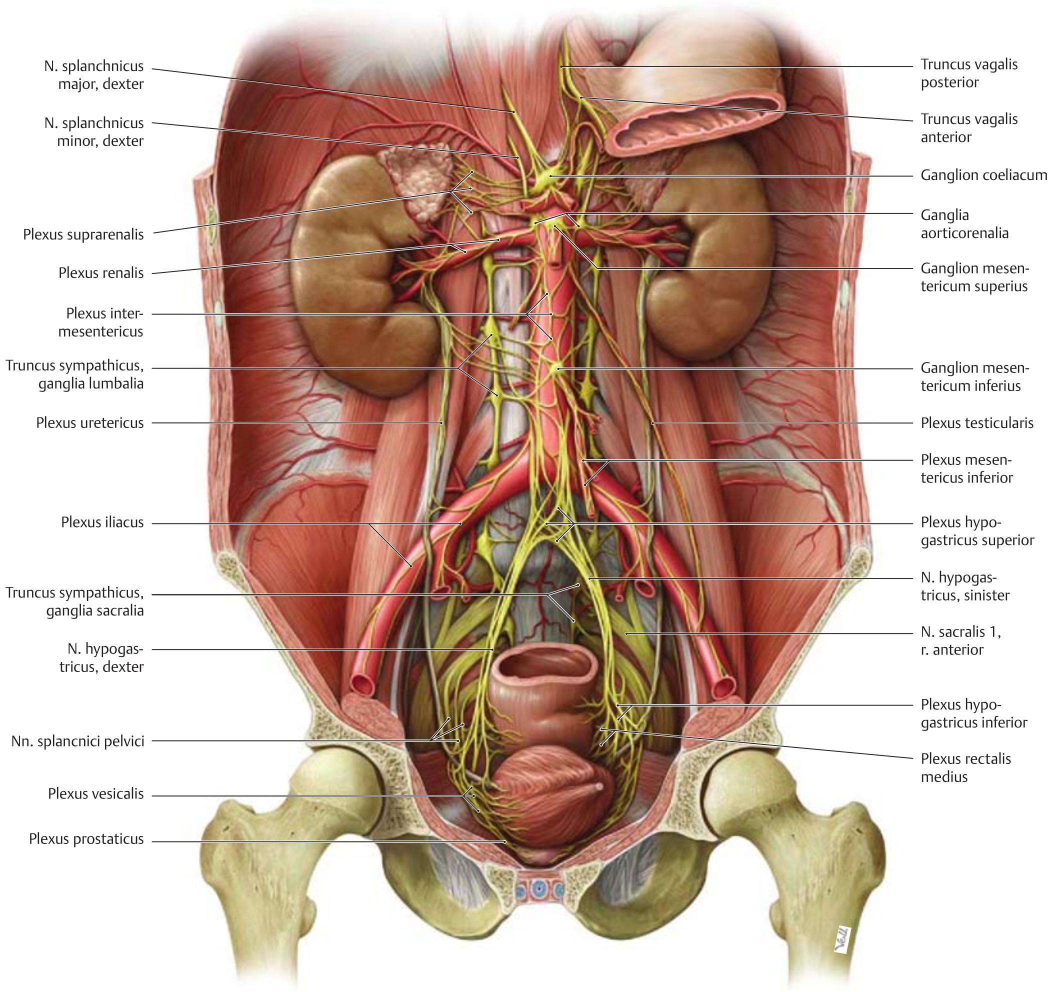


Fig. 17.3 **Innervation of the urinary organs**
Anterior view of the male abdomen and pelvis. *Removed:* Abdominal organs and peritoneum. See p. 246 for schematic.



Innervation of the Intestines

Fig. 17.4 **Innervation of the intestinum tenue**
Anterior view. *Partially removed:* Gaster, pancreas, and colon transversum (distal part). See p. 245 for schematic.

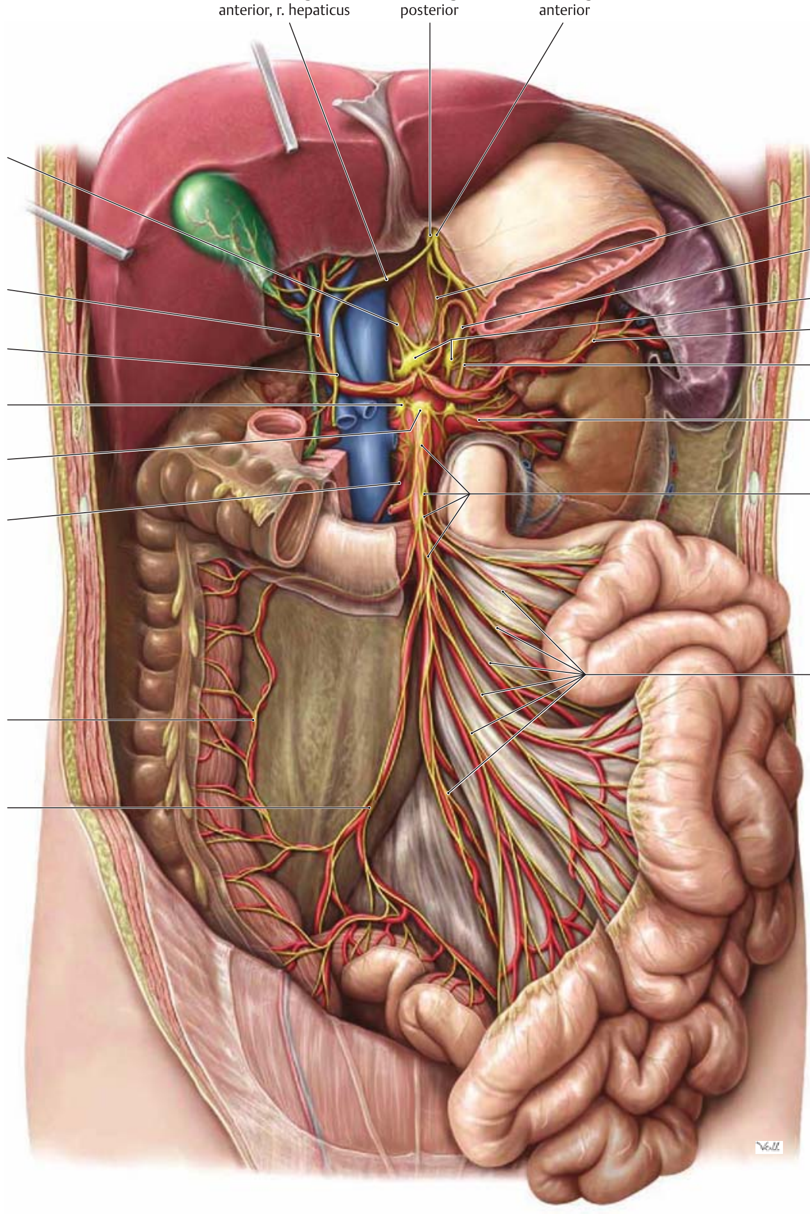
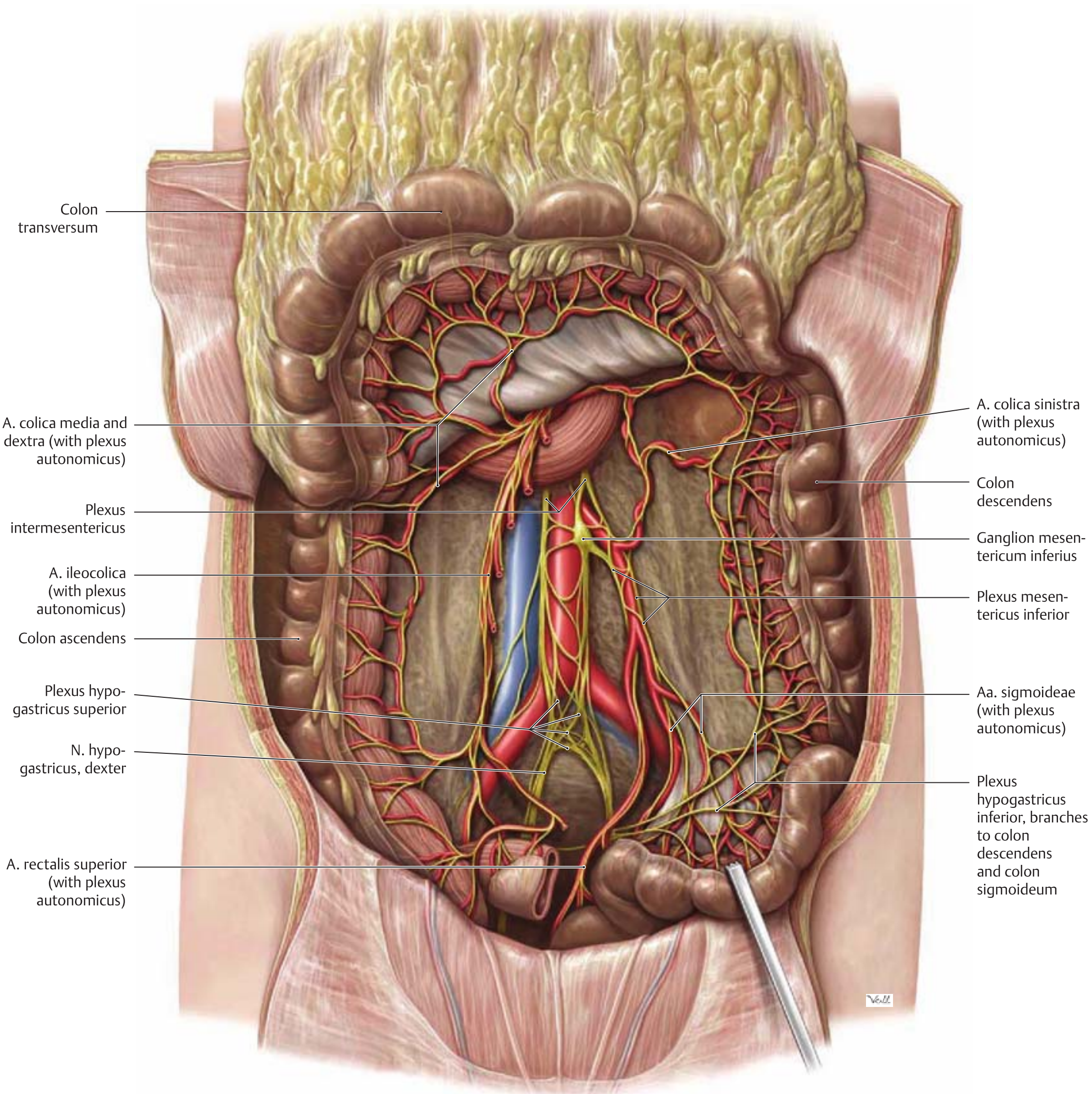


Fig. 17.5 **Innervation of the intestinum crassum**
Anterior view. *Removed:* Jejunum and ileum. *Reflected:* Colon transversum and sigmoideum. See p. 245 for schematic.



Innervation of the Pelvis

Fig. 17.6 **Innervation of the female pelvis**
Right pelvis, left lateral view. *Reflected:* Uterus and rectum.
See p. 247 for schematic.

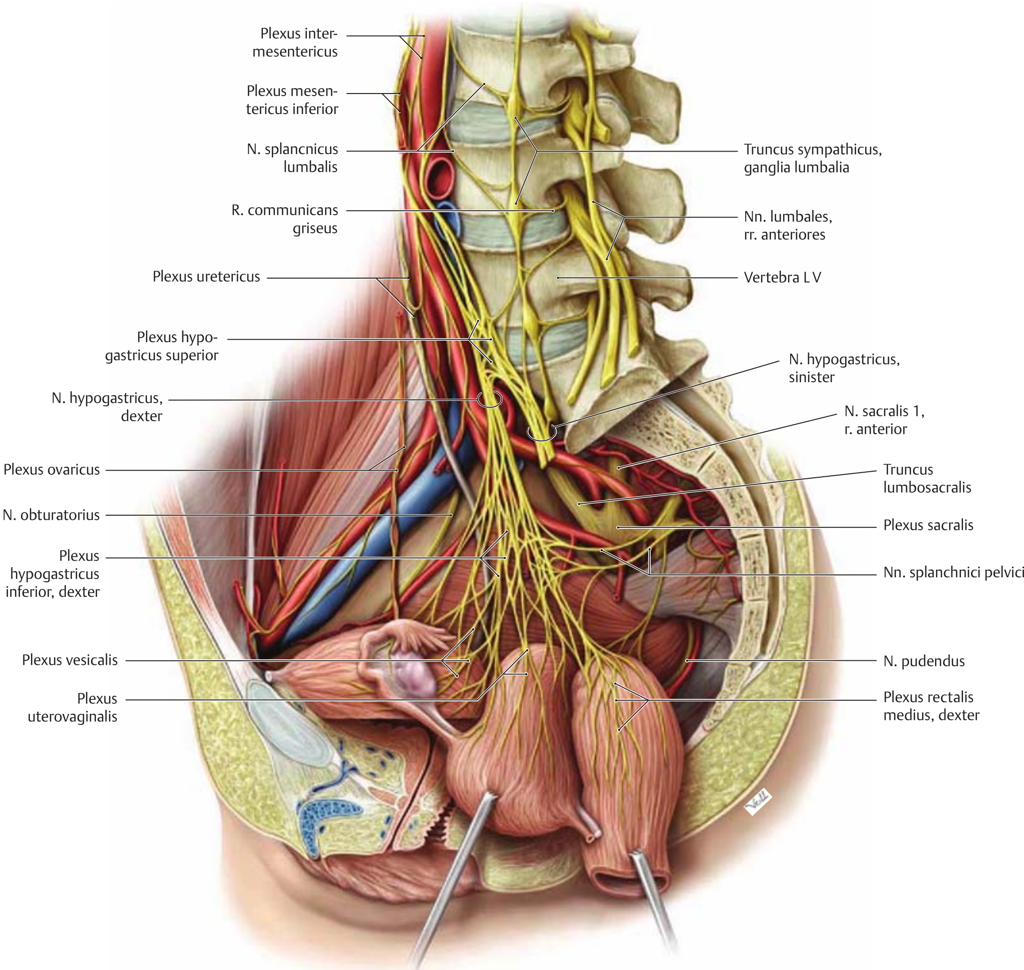
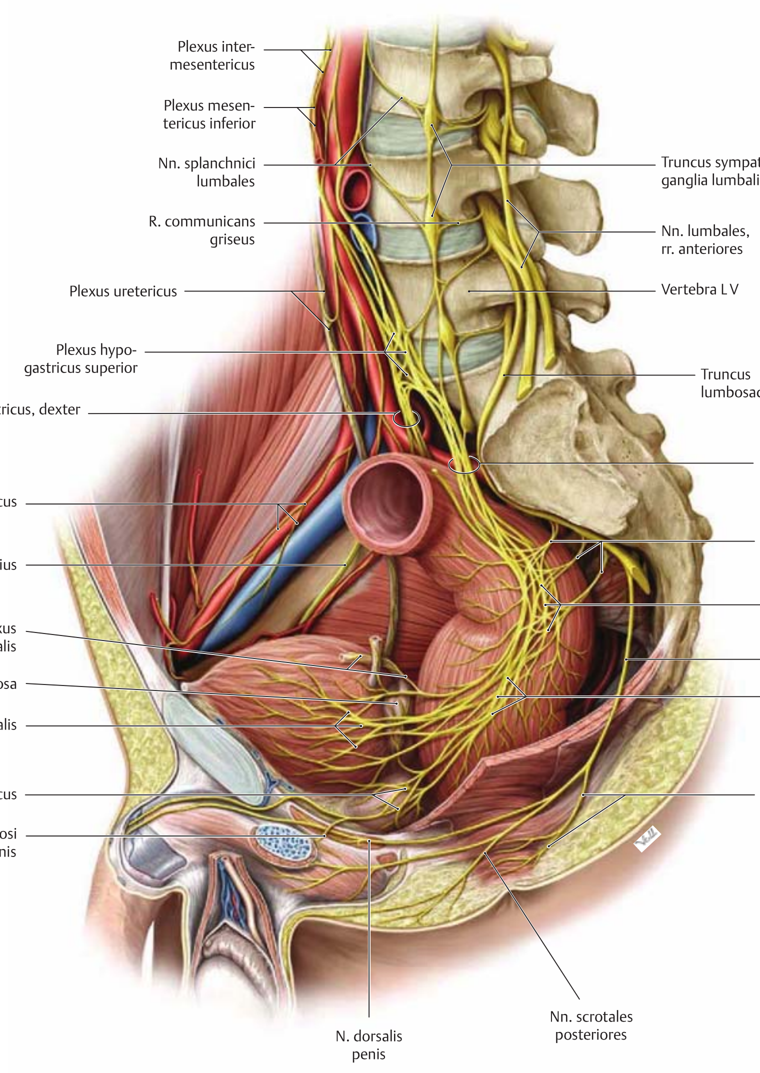
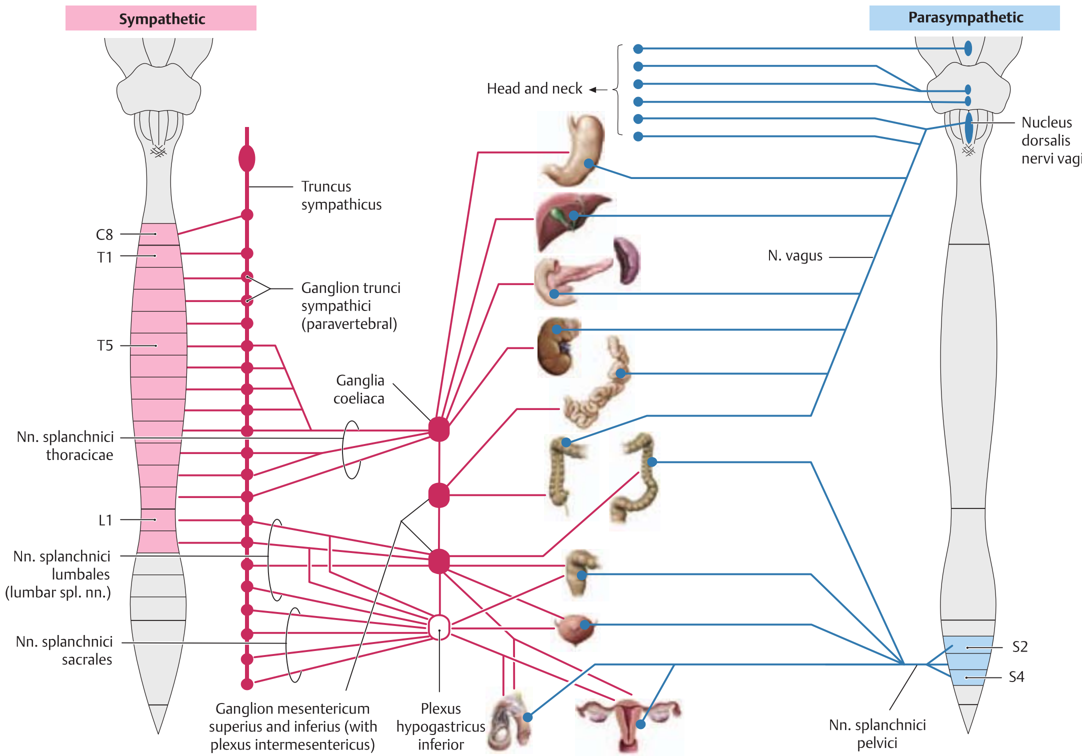


Fig. 17.7 **Innervation of the male pelvis**
Right pelvis, left lateral view. See p. 247 for schematic.



Autonomic Innervation: Overview

Fig. 17.8 **Sympathetic and parasympathetic nervous systems in the abdomen and pelvis**

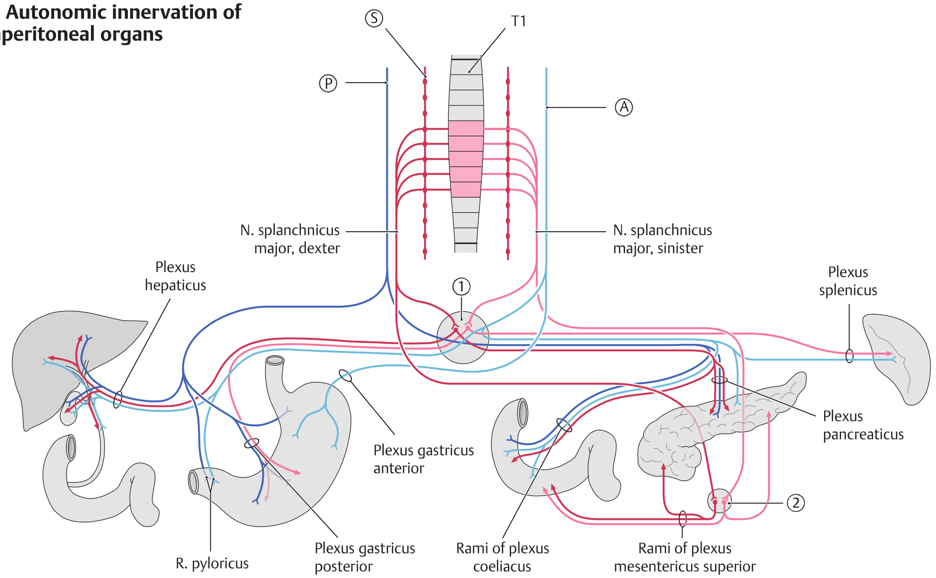


A Sympathetic nervous system.

B Parasympathetic nervous system.

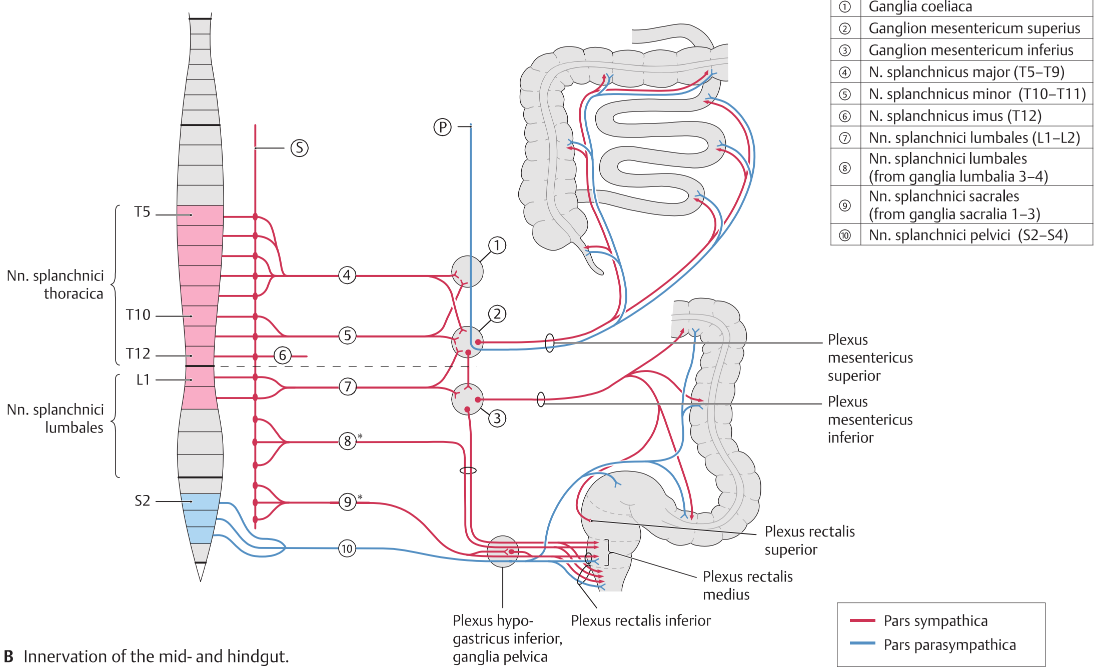
Table 17.2	**Effects of the autonomic nervous system in the abdomen and pelvis**		
Organ (organ system)		**Sympathetic effect**	**Parasympathetic effect**
Gastrointestinal tract	Longitudinal and circular muscle fibers	Decreases motility	Increases motility
	Musculi sphincteri	Contraction	Relaxation
	Glandulae	Decreases secretions	Increases secretions
Capsula splenica		Contraction	No effect
Hepar		Increases glycogenolysis/gluconeogenesis	
Pancreas	Endocrine pancreas	Decreases insulin secretion	
	Exocrine pancreas	Decreases secretion	Increases secretion
Vesica urinaria	M. detrusor vesicae	Relaxation	Contraction
	Functional bladder sphincter	Contraction	Inhibits contraction
Glandula vesiculosa and ductus deferens		Contraction (ejakulation)	No effect
Uterus		Contraction or relaxation, depending on hormonal status	
Arteriae		Vasoconstriction	Vasodilation of the arteriae of the penis and clitoris (erection)
Glandula suprarenalis (medulla)		Release of adrenalin	No effect
Urinary tract	Ren	Vasokonstriction (decreases urine formation)	Vasodilation

Fig. 17.9 **Autonomic innervation of the intraperitoneal organs**



A Innervation of the foregut. As the left and right nn. vagus descend along the esophagus, they become truncus vagalis anterior and posterior, respectively. Each trunk produces a r. coeliacus, r. pyloricus and r. hepaticus, and a plexus gastricus.

Ⓢ	Truncus sympathicus
Ⓟ	Truncus vagalis posterior (n. vagus, dexter)
Ⓐ	Truncus vagalis anterior (n. vagus, sinister)
①	Ganglia coeliaca
②	Ganglion mesentericum superius
③	Ganglion mesentericum inferius
④	N. splanchnicus major (T5–T9)
⑤	N. splanchnicus minor (T10–T11)
⑥	N. splanchnicus imus (T12)
⑦	Nn. splanchnici lumbales (L1–L2)
⑧	Nn. splanchnici lumbales (from ganglia lumbalia 3–4)
⑨	Nn. splanchnici sacrales (from ganglia sacralia 1–3)
⑩	Nn. splanchnici pelvici (S2–S4)

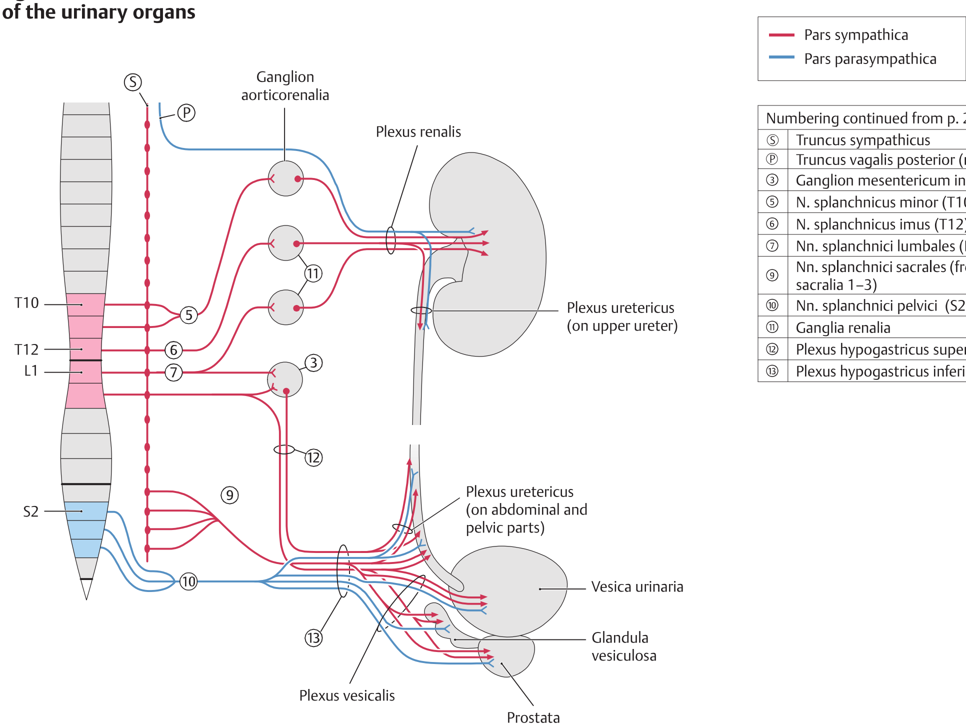


B Innervation of the mid- and hindgut.

*Synapse in the lumbar sympathetic ganglia.

Autonomic Innervation: Urinary & Genital Organs

Fig. 17.10 Autonomic innervation of the urinary organs



	Numbering continued from p. 245.
Ⓢ	Truncus sympathicus
Ⓟ	Truncus vagalis posterior (n. vagus, dexter)
③	Ganglion mesentericum inferius
⑤	N. splanchnicus minor (T10–T11)
⑥	N. splanchnicus imus (T12)
⑦	Nn. splanchnici lumbales (L1–L2)
⑨	Nn. splanchnici sacrales (from ganglia sacralia 1–3)
⑩	Nn. splanchnici pelvici (S2–S4)
⑪	Ganglia renalia
⑫	Plexus hypogastricus superior
⑬	Plexus hypogastricus inferior

Clinical

Referred pain from the internal organs

The convergence of somatic and visceral afferent fibers to a common level of the spinal cord confuses the relationship between the perceived and actual sites of pain, a phenomenon known as referred pain. Pain impulses from a particular organ are consistently projected to the same well-defined skin area.

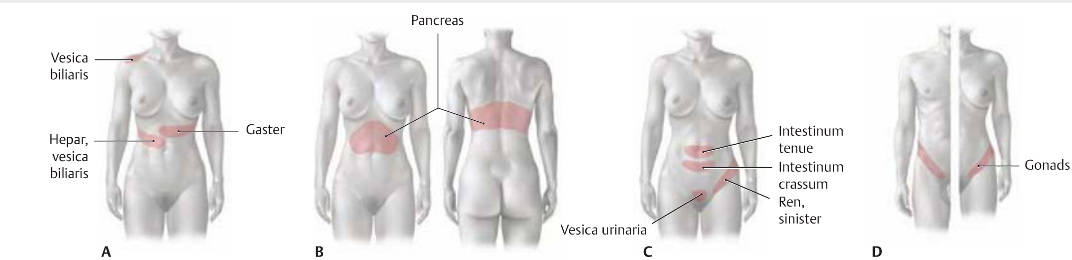
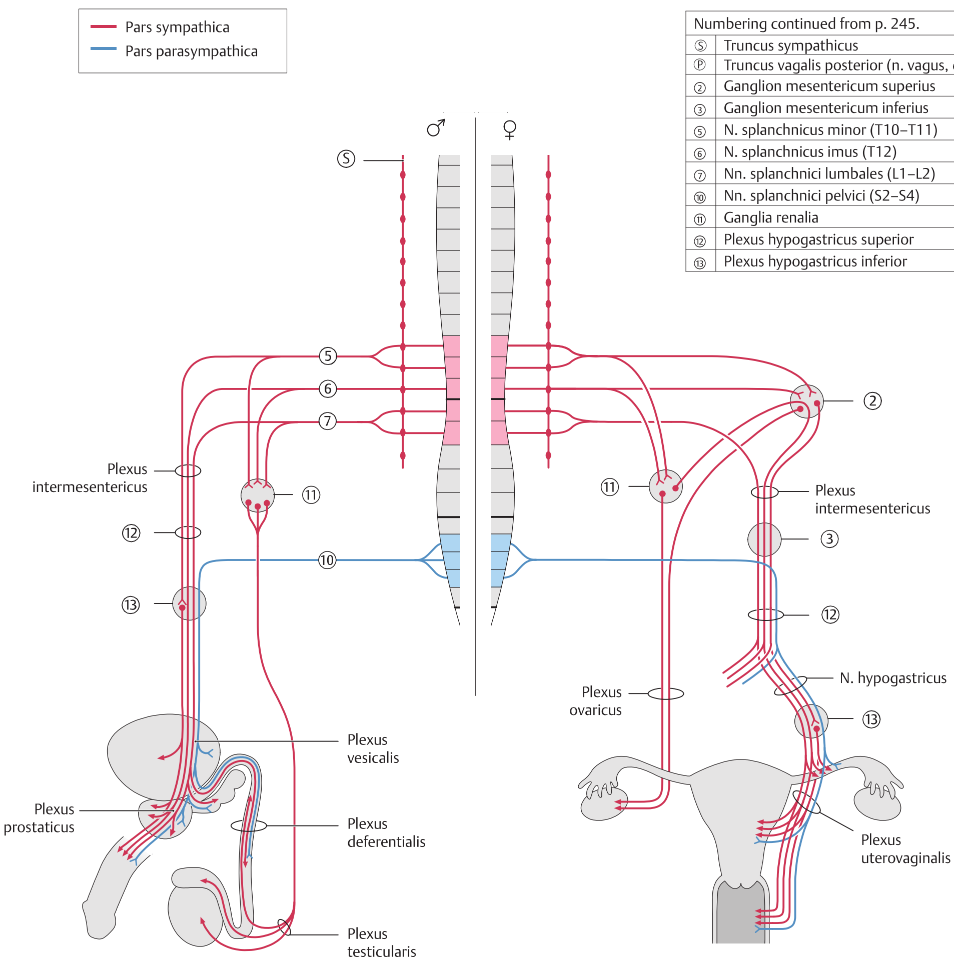


Fig. 17.11 Autonomicinnervation of the genitalia

Numbering continued from p. 245.	
Ⓢ	Truncus sympathicus
Ⓟ	Truncus vagalis posterior (n. vagus, dexter)
②	Ganglion mesentericum superius
③	Ganglion mesentericum inferius
⑤	N. splanchnicus minor (T10–T11)
⑥	N. splanchnicus imus (T12)
⑦	Nn. splanchnici lumbales (L1–L2)
⑩	Nn. splanchnici pelvici (S2–S4)
⑪	Ganglia renalia
⑫	Plexus hypogastricus superior
⑬	Plexus hypogastricus inferior

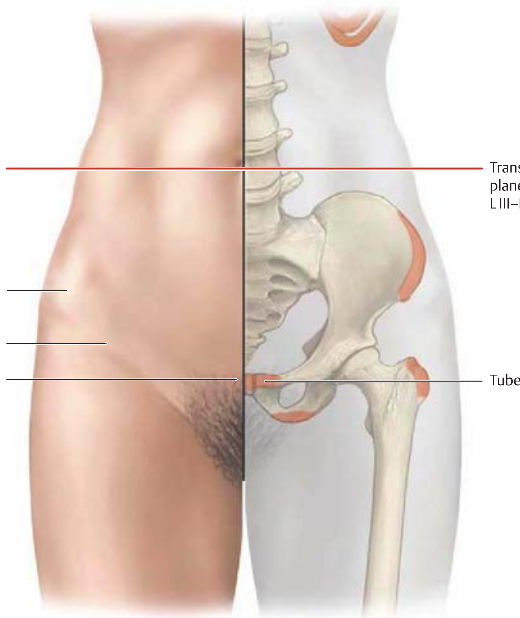


A Male genitalia.

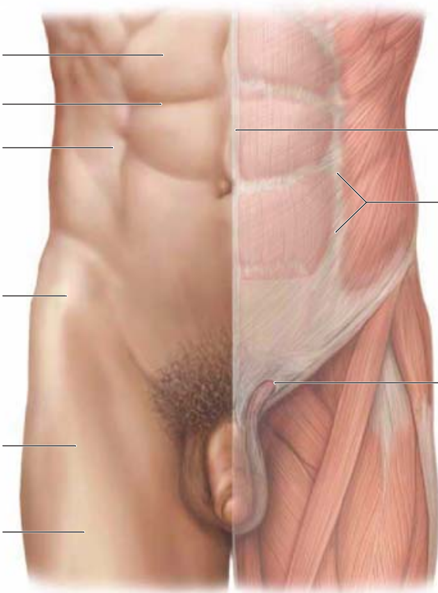
B Female genitalia.

Surface Anatomy

Fig. 18.1 **Palpable structures in the abdomen and pelvis**
Anterior view. See pp. 40–41 for structures of the back.



A Bony prominences.



B Musculature.

Fig. 18.2 **Surface anatomy of the abdomen and pelvis**
Anterior view. See pp. 40–41 for structures of the back.

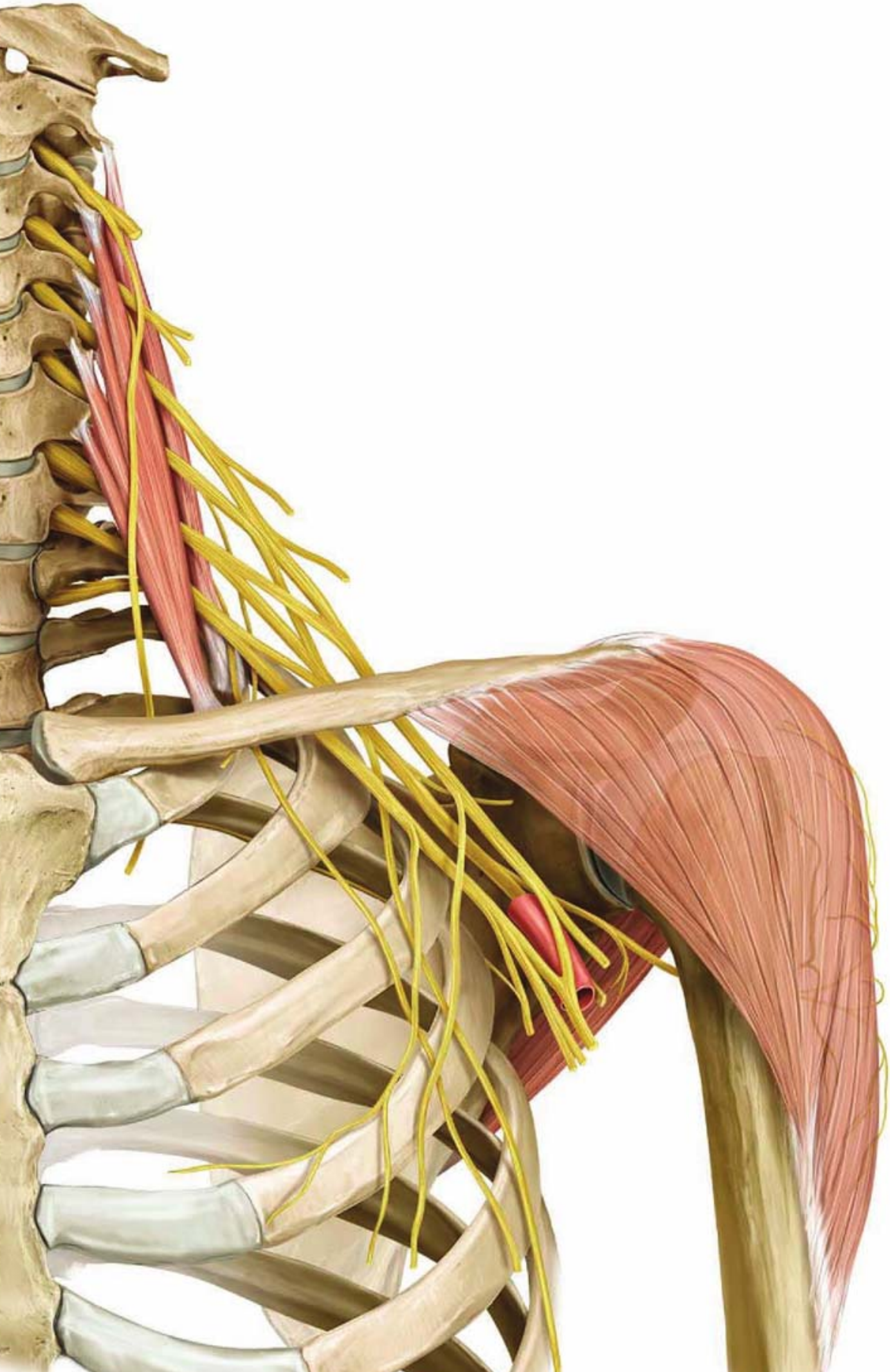
A Female abdomen and pelvis.

Q1: How would this patient's abdomen be subdivided for descriptive purposes into four quadrants? Name five organs in each quadrant.

Q2: A patient's inguinal region shows a slight swelling just superior to the middle of the inguinal region. What factors (age, anatomical) might assist you in determining if this is a direct or indirect inguinal hernia?

B Male abdomen and pelvis.

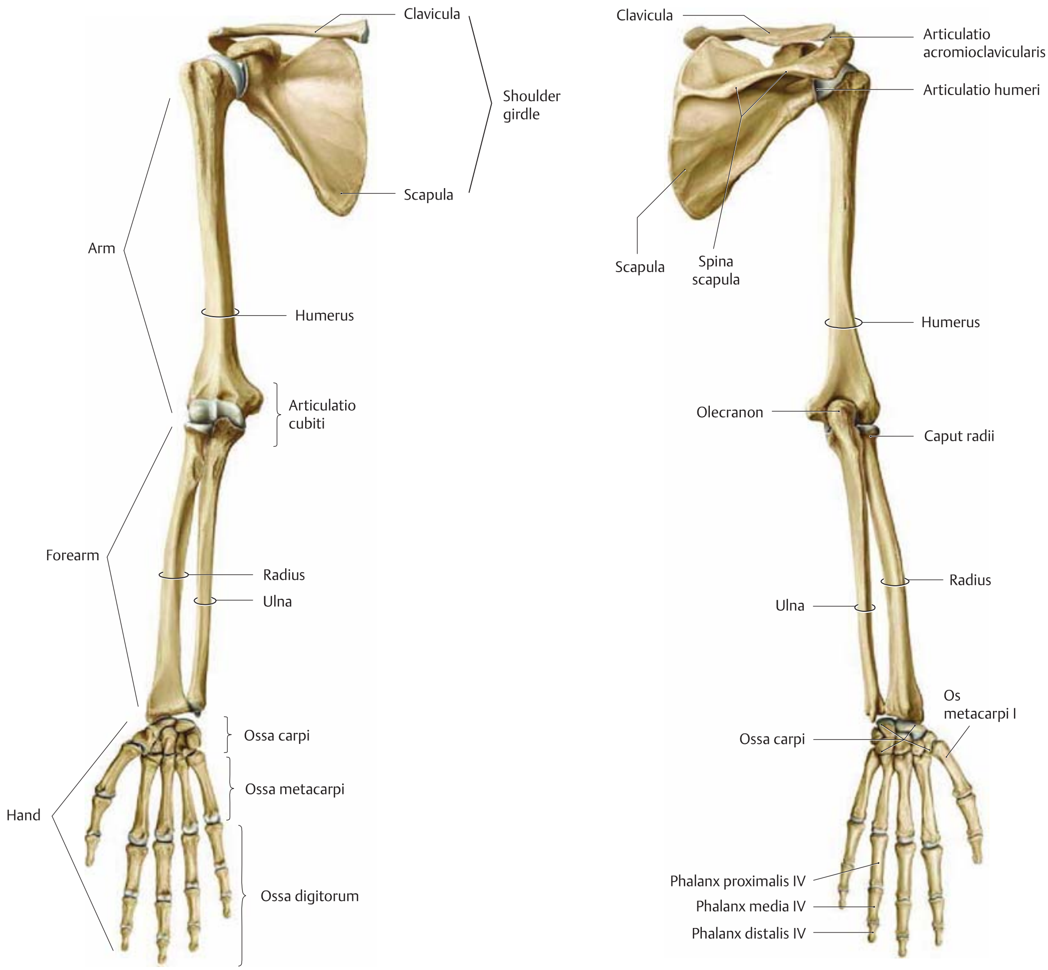
See answers beginning on p. 626.



Upper Limb

Bones of the Upper Limb

Fig. 19.1 **Skeleton of the upper limb**
Right limb. The upper limb is subdivided into three regions: arm, forearm, and hand. The shoulder girdle (clavicula and scapula) joins the upper limb to the thorax at articulatio sternoclavicularis.

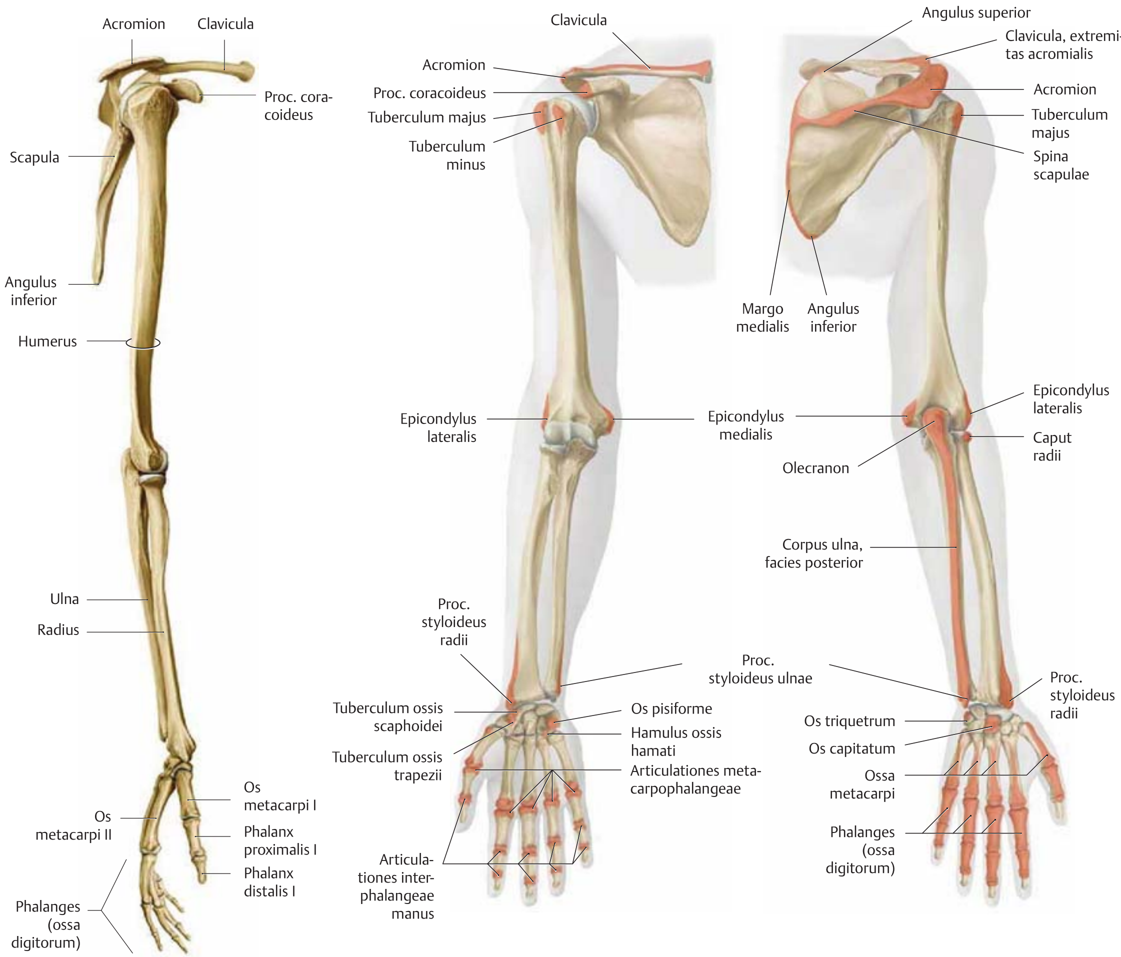


A Anterior view.

B Posterior view.

Fig. 19.2 **Palpable bony prominences**

Except for the os lunatum and os trapezoideum, all of the bones in the upper limb are palpable to some degree through the skin and soft tissues.



C Lateral view.

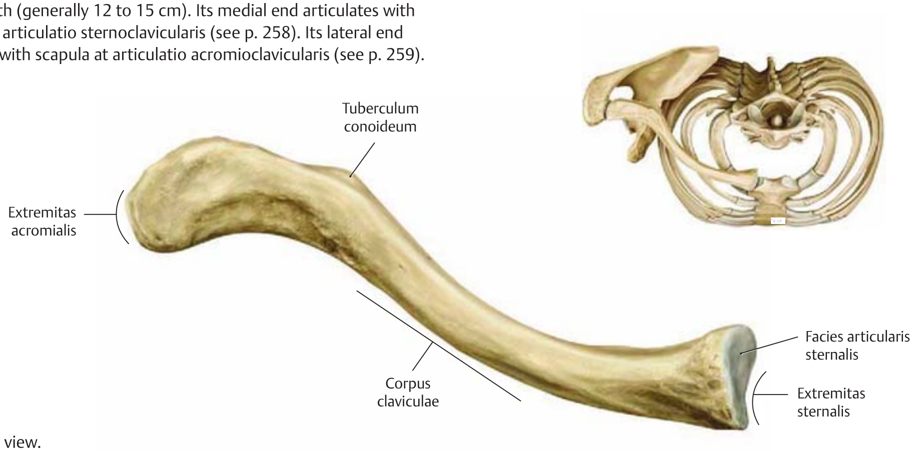
A Anterior view.

B Posterior view.

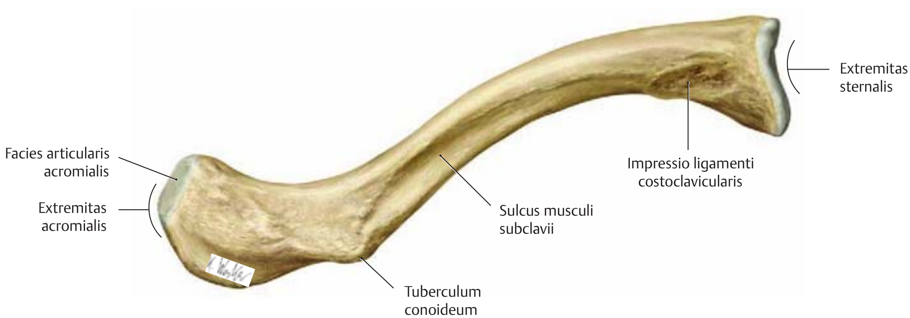
Clavicula & Scapula

The shoulder girdle (clavicula and scapula) connects the bones of the upper limb to the thoracic cage. Whereas the pelvic girdle (paired hip bones) is firmly integrated into the axial skeleton (see p. 358), the shoulder girdle is extremely mobile.

Fig. 19.3 **Clavicula**
Right clavicula. The S-shaped clavicle is visible and palpable along its entire length (generally 12 to 15 cm). Its medial end articulates with sternum at articulatio sternoclavicularis (see p. 258). Its lateral end articulates with scapula at articulatio acromioclavicularis (see p. 259).



A Superior view.



B Inferior view.

Clinical

Foramen scapulae
Lig. transversum scapulae superius (see p. 259) may become ossified, transforming incisura scapulae into an anomalous bony canal, foramen scapulae. This can lead to compression of n. suprascapularis as it passes through the canal (see p. 333).

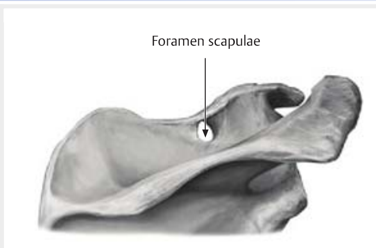
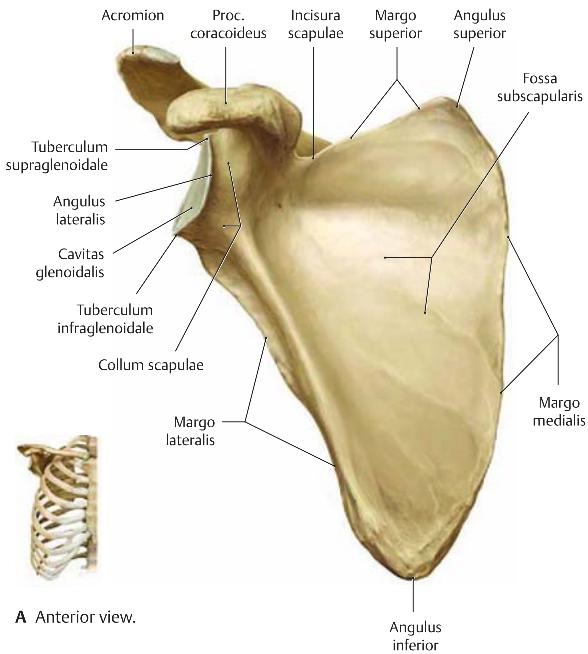
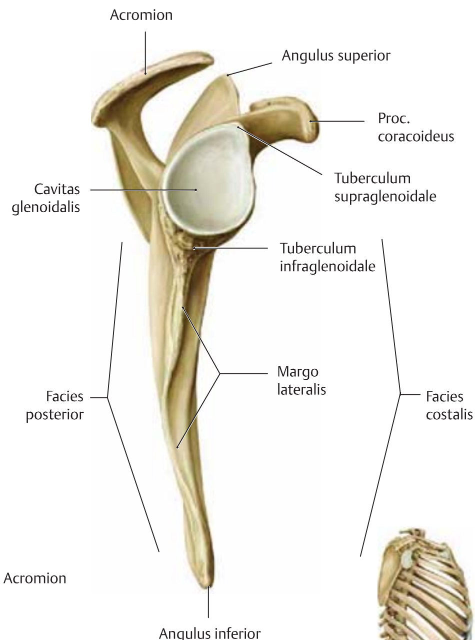


Fig. 19.4 **Scapula**

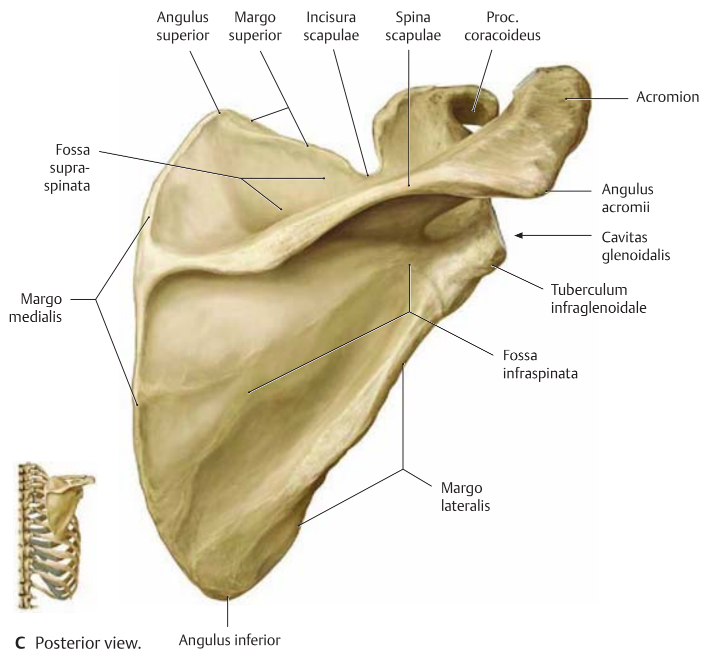
Right scapula. In its normal anatomical position, the scapula extends from costa II to costa VII.



A Anterior view.



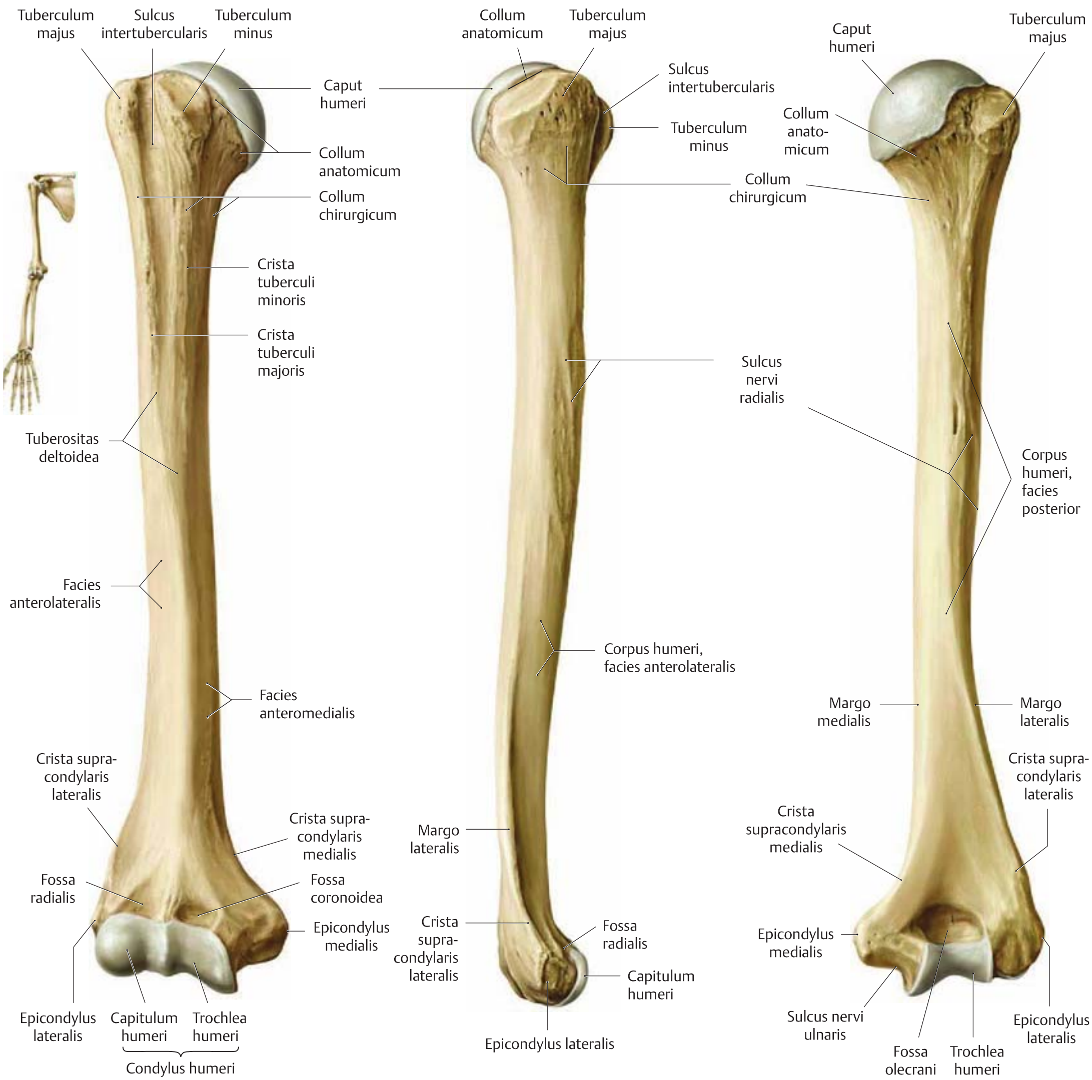
B Right lateral view.



C Posterior view.

Humerus

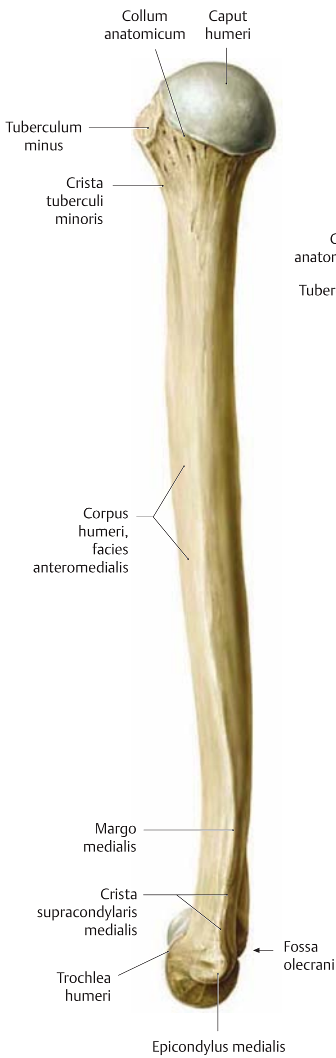
Fig. 19.5 **Humerus**
Right humerus. The caput humeri articulates with scapula at articulatio humeri (see p. 258). The capitulum and trochlea humeri articulate with radius and ulna, respectively, at articulatio cubiti (see p. 282).



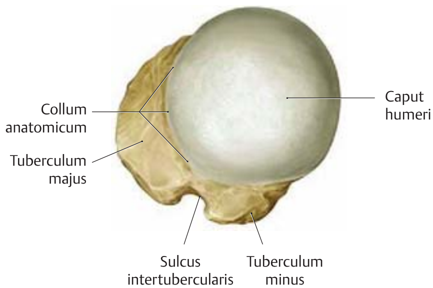
A Anterior view.

B Lateral view.

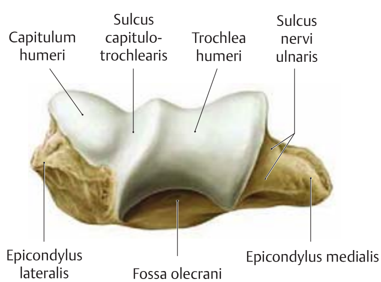
C Posterior view.



D Medial view.



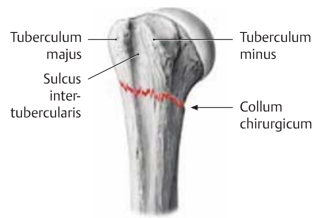
E Proximal (superior) view.



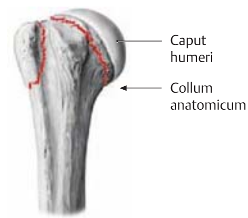
F Distal (inferior) view.

Clinical

Fractures of the humerus
Anterior view. Fractures of the proximal humerus are very common and occur predominantly in older patients who sustain a fall onto the outstretched arm or directly onto the shoulder. Three main types are distinguished.



A Extra-articular fracture.



B Intra-articular fracture.

C Comminuted fracture.

Extra-articular fractures and intra-articular fractures are often accompanied by injuries of the blood vessels that supply the humeral head (aa. circumflexa humeri anterior and posterior), with an associated risk of post-traumatic avascular necrosis.

Fractures of the humeral shaft and distal humerus are frequently associated with damage to the radial nerve.

Joints of the Shoulder

Fig. 19.6 **Joints of the shoulder: Overview**
Right shoulder, anterior view.

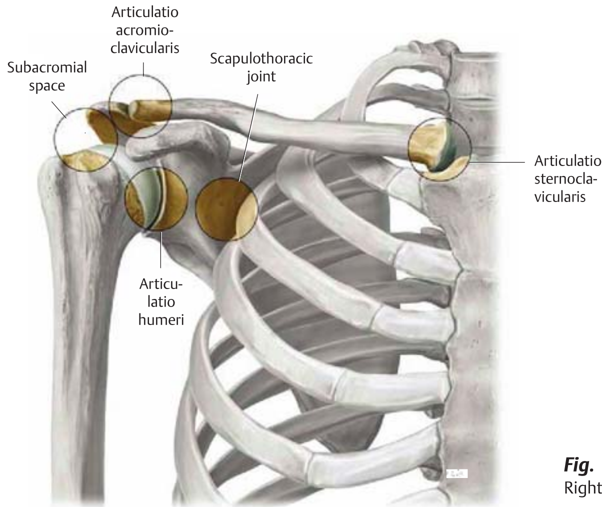


Fig. 19.7 **Joints of the shoulder girdle**
Right side, superior view.

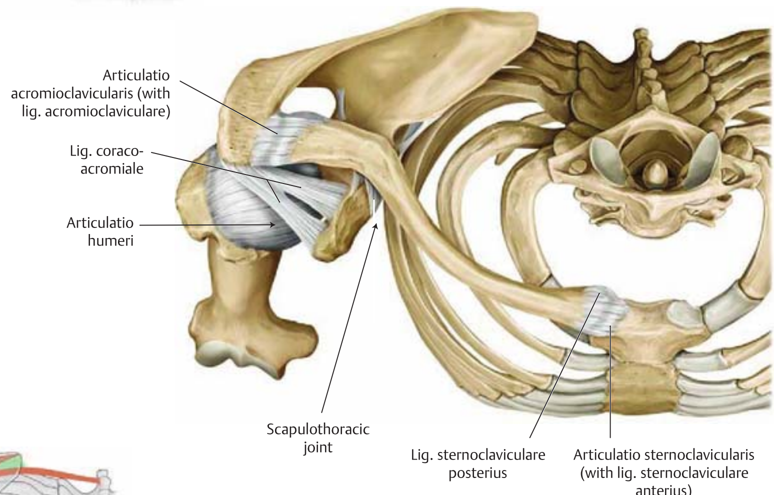


Fig. 19.8 **Scapulothoracic joint**
Right side, superior view. In all movements of the shoulder girdle, scapula glides on a curved surface of loose connective tissue between m. serratus anterior and m. sub-scapularis. This surface can be considered a scapulothoracic joint.

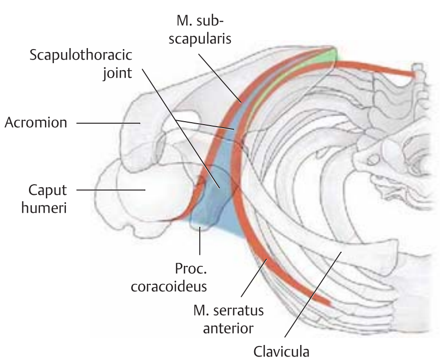


Fig. 19.9 Articulatio sterno-claviculāris

Anterior view with sternum coronally sectioned (left). *Note:* A fibrocartilaginous discus articularis compensates for the mismatch of surfaces between the two saddle-shaped articular facets of clavicula and manubrium sterni.

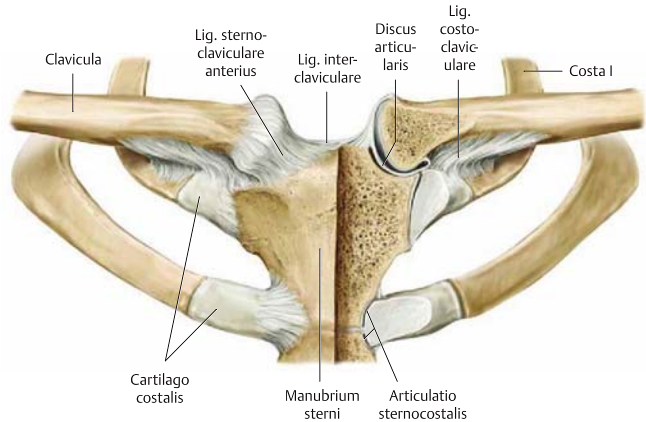
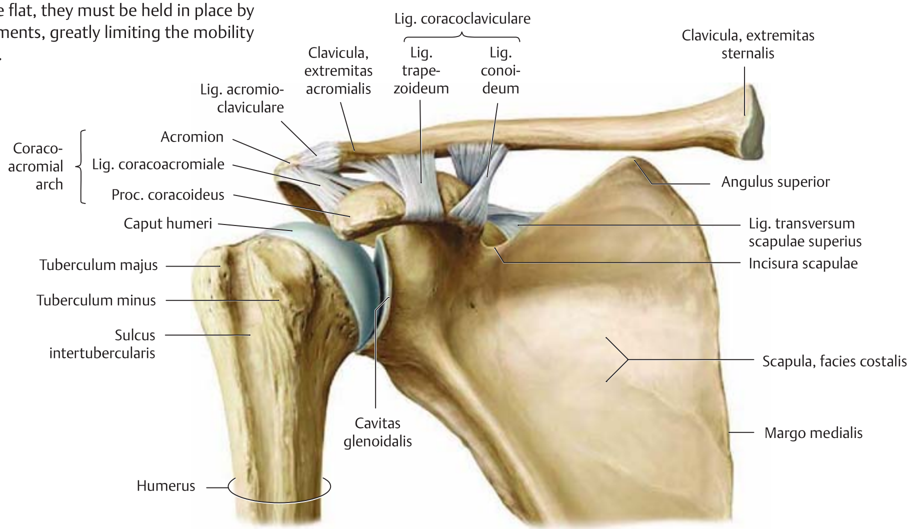


Fig. 19.10 Articulatio acromio-clavicularis

Anterior view. Articulatio acromioclavicularis is a plane joint. Because the articulating surfaces are flat, they must be held in place by strong ligaments, greatly limiting the mobility of the joint.



Clinical

Injuries of articulatio acromioclavicularis

A fall onto the outstretched arm or shoulder frequently causes dislocation of articulatio acromioclavicularis and damage to Ligg. coracoclaviculare and acromioclaviculare.

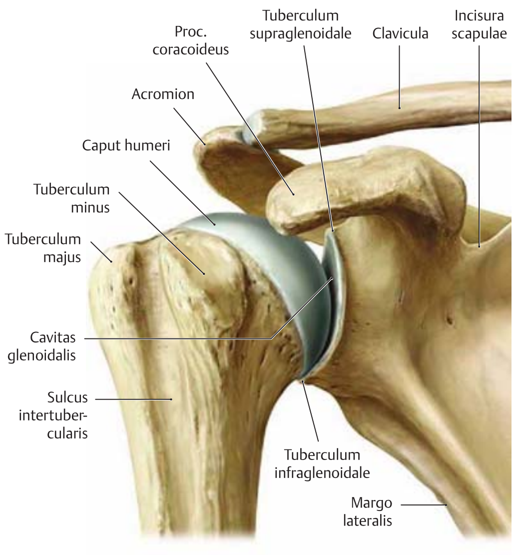
A Stretching of ligaments.

B Rupture of Lig. acromioclaviculare.

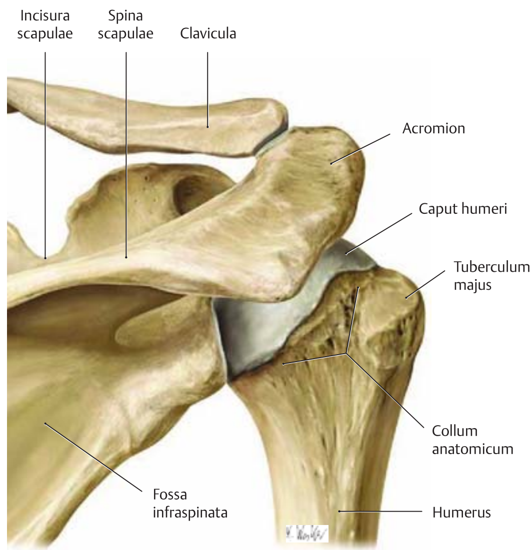
C Complete dislocation of articulatio acromioclavicularis.

Joints of the Shoulder: Articulatio Humeri

Fig. 19.11 **Articulatio humeri: Bony elements**
Right shoulder.



A Anterior view.



B Posterior view.

Fig. 19.12 **Radiograph of the shoulder**
Anteroposterior view.

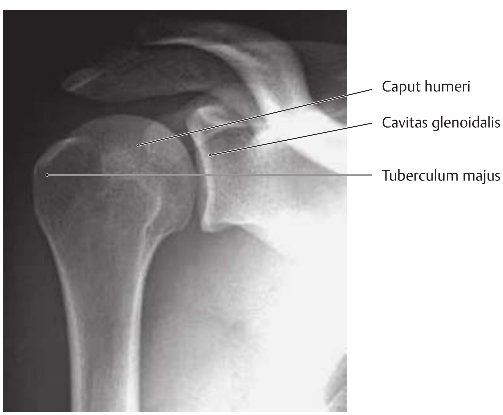
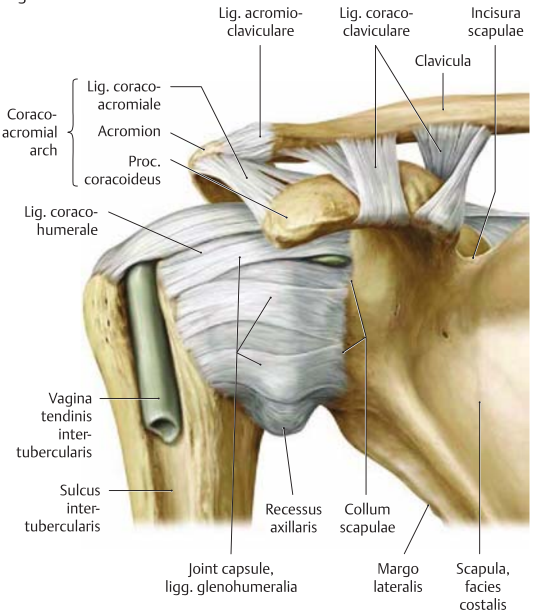
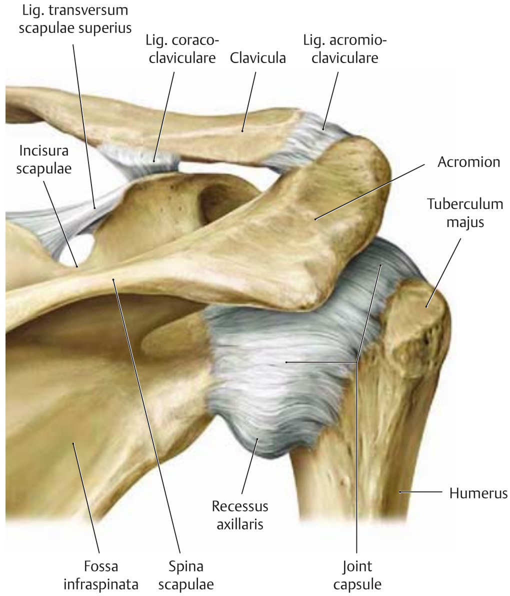


Fig. 19.13 Articulatio humeri: Capsule and ligaments

Right shoulder.



A Anterior view.



B Posterior view.

Fig. 19.14 Articulatio humeri: Joint cavity

Anterior view.

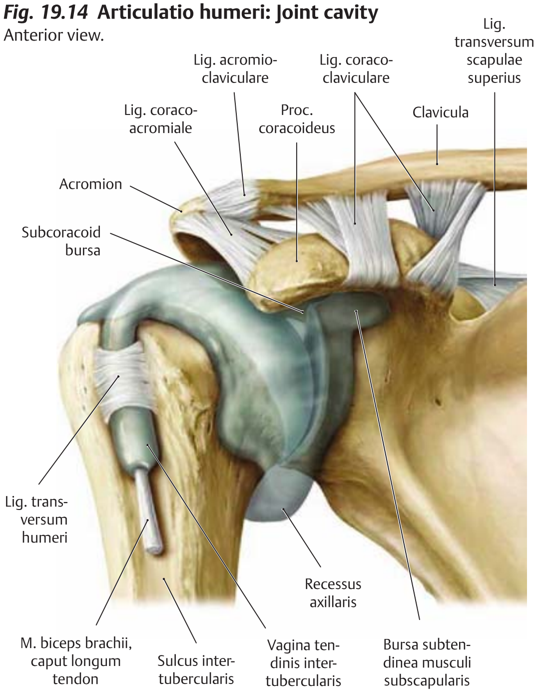
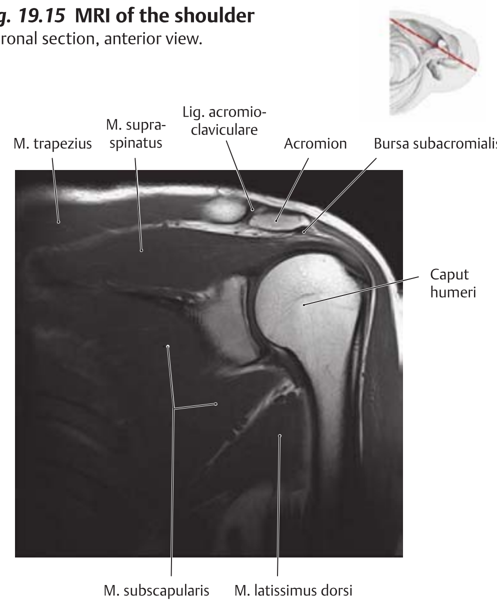


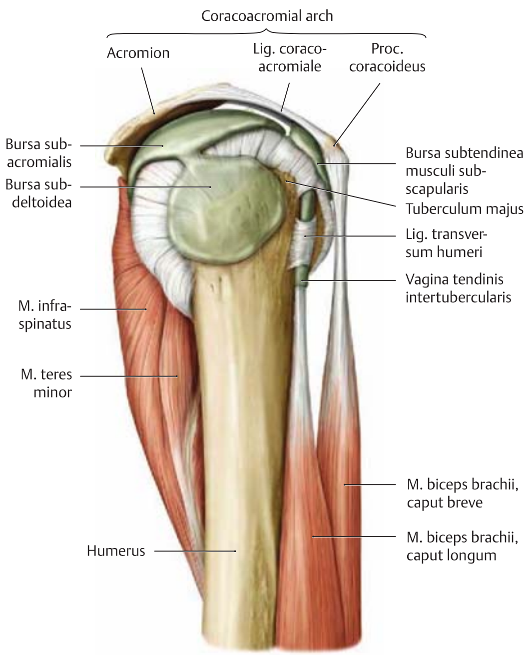
Fig. 19.15 MRI of the shoulder

Coronal section, anterior view.



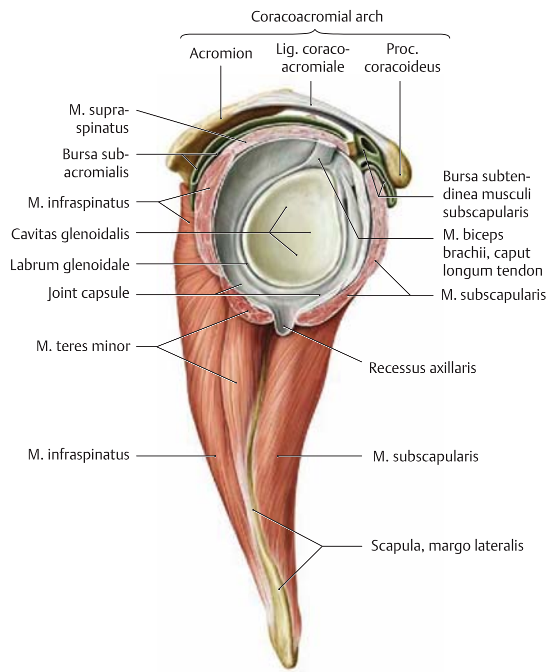
Subacromial Space & Bursae

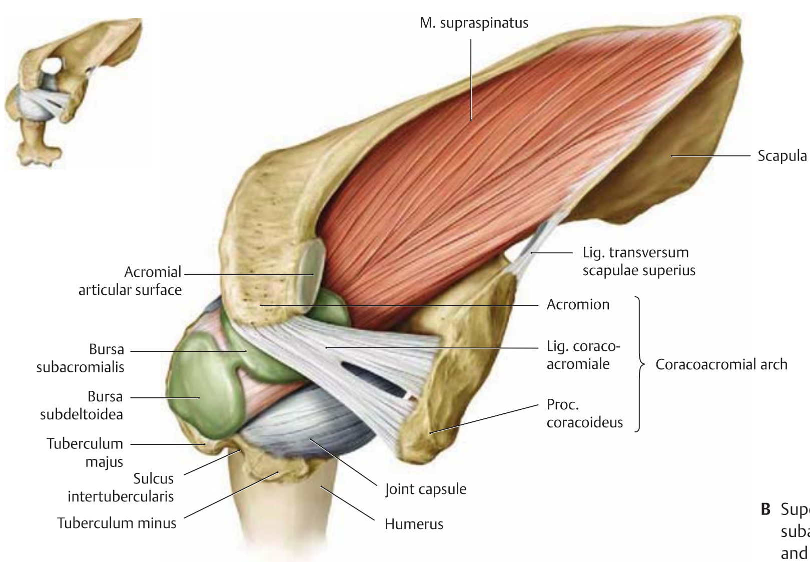
Fig. 19.16 **Subacromial space**
Right shoulder.



A Lateral view.

Fig. 19.17 **Bursa subacromialis and cavitas glenoidalis**
Right shoulder, lateral view of sagittal section with humerus removed.

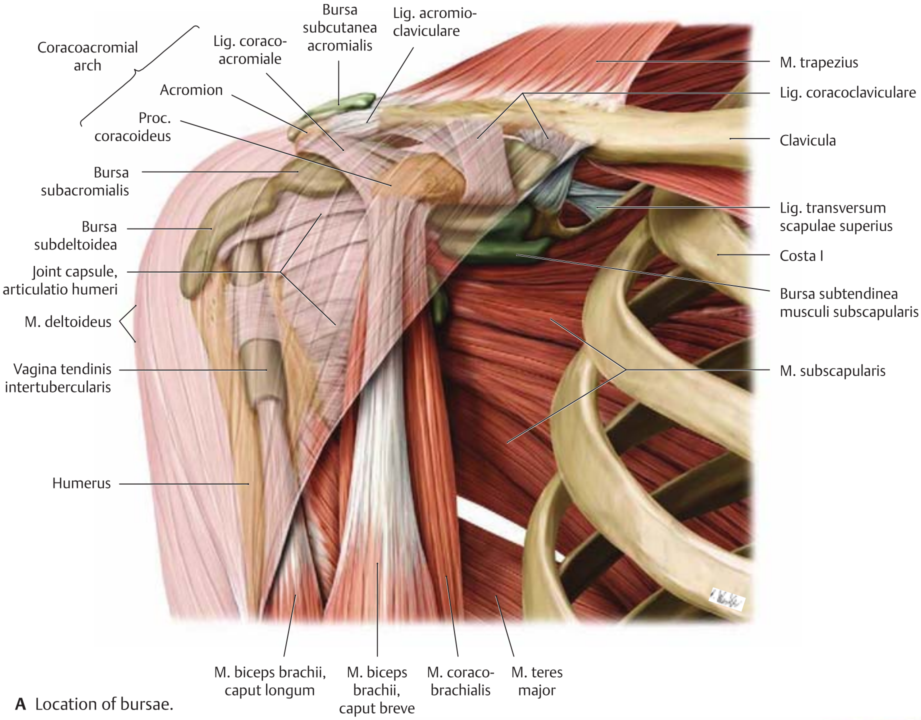




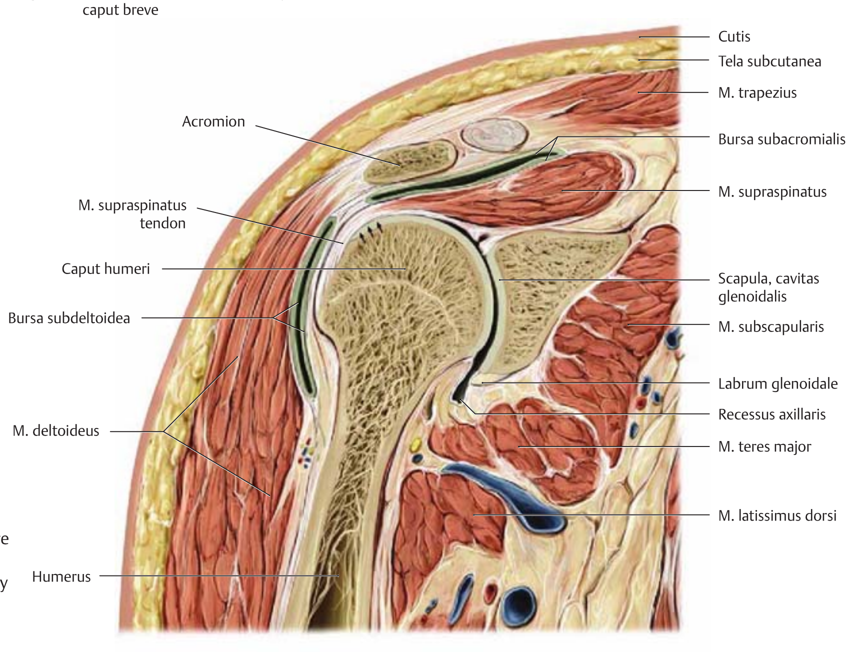
B Superior view. Note the position of bursa subacromialis between m. supraspinatus and the coracoacromial arch.

Fig. 19.18 **Bursae subacromialis and subdeltoidea**

Right shoulder, anterior view.



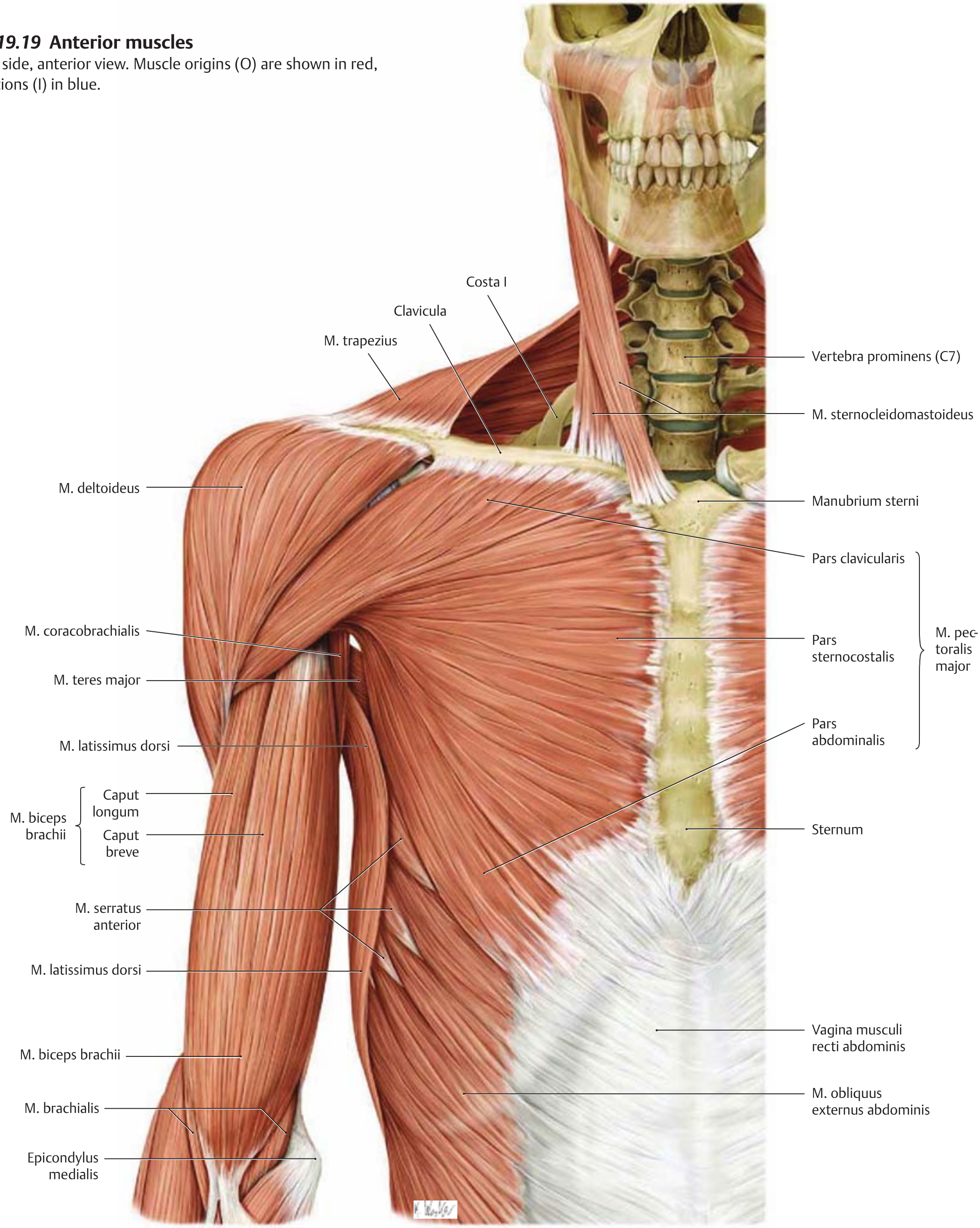
A Location of bursae.



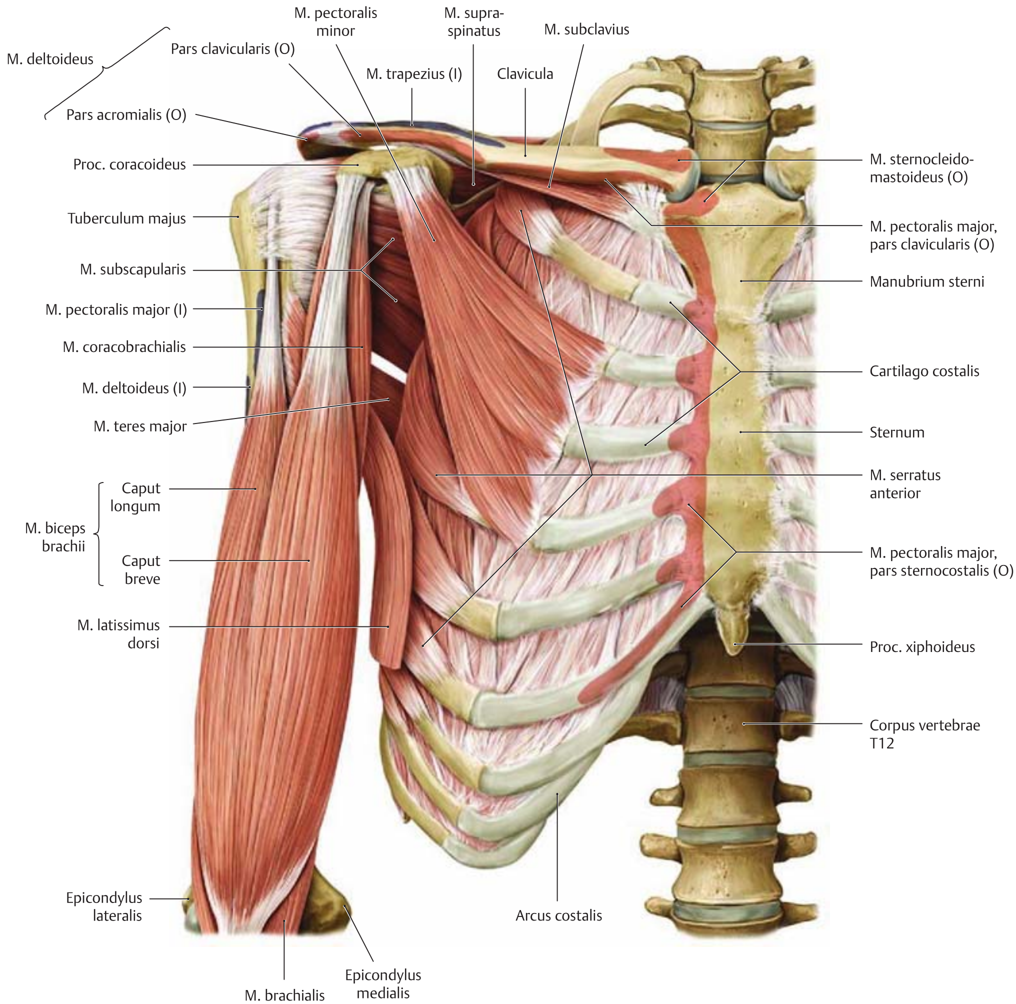
B Coronal section. The arrows are pointing at the m. supraspinatus tendon, which is frequently injured in a “rotator cuff tear” (for rotator cuff, see p. 273).

Anterior Muscles of the Shoulder & Arm (I)

Fig. 19.19 **Anterior muscles**
Right side, anterior view. Muscle origins (O) are shown in red, insertions (I) in blue.



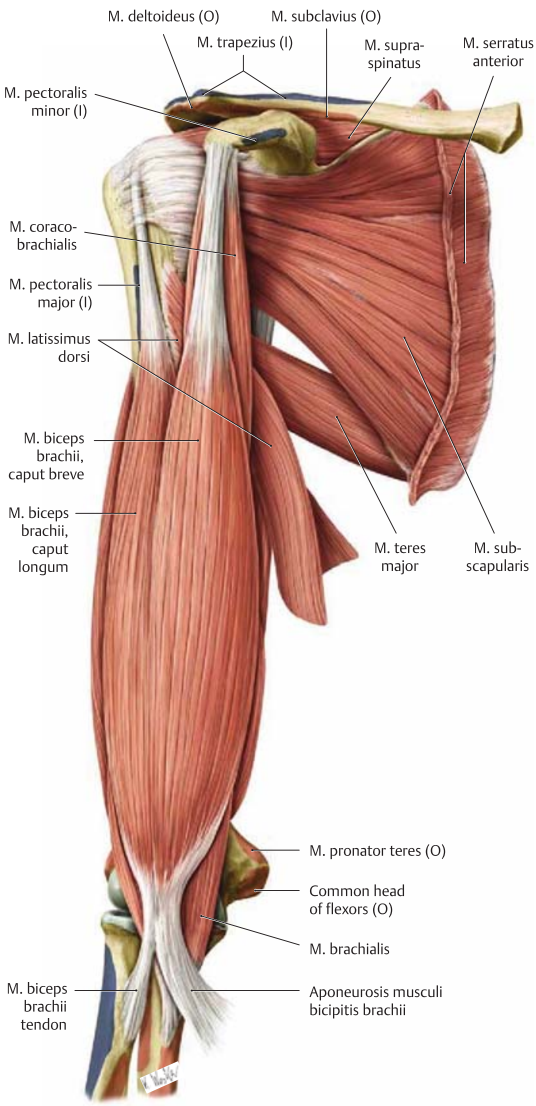
A Superficial dissection.



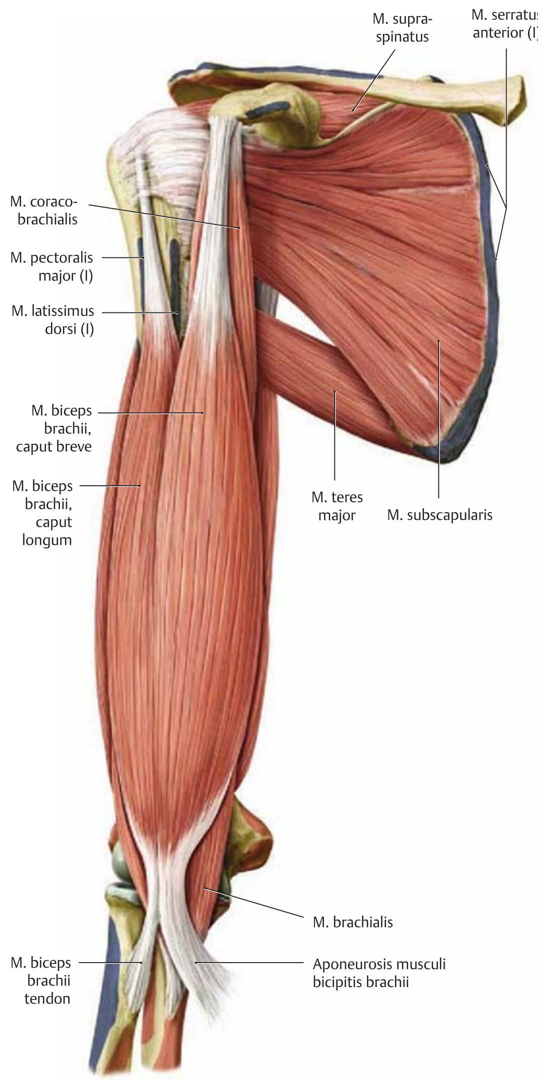
B Deep dissection. *Removed:* M. sternocleidomastoideus, m. trapezius, m. pectoralis major, m. deltoideus, and m. obliquus externus abdominis.

Anterior Muscles of the Shoulder & Arm (II)

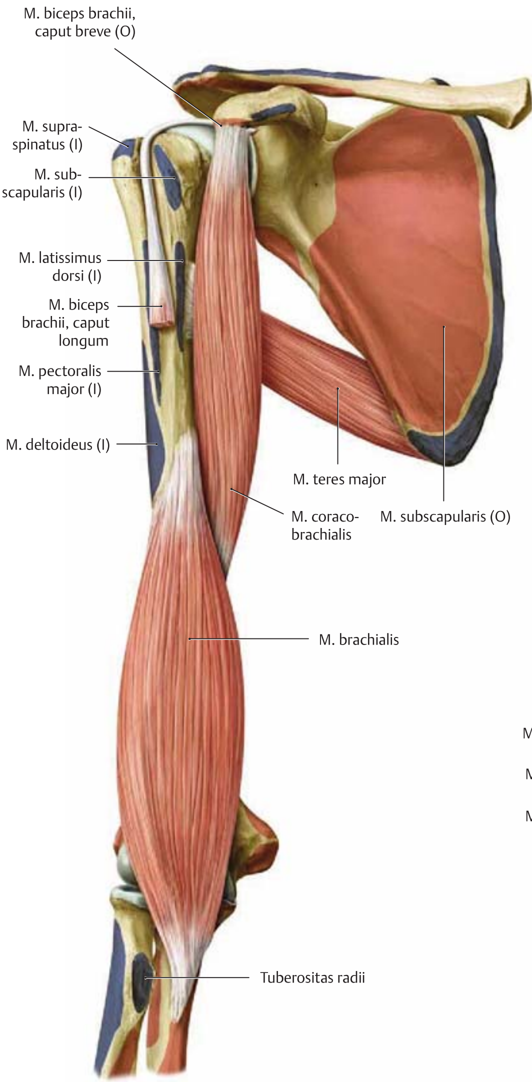
Fig. 19.20 **Anterior dissection**
Right arm, anterior view. Muscle origins (O) are shown in red, insertions (I) in blue.



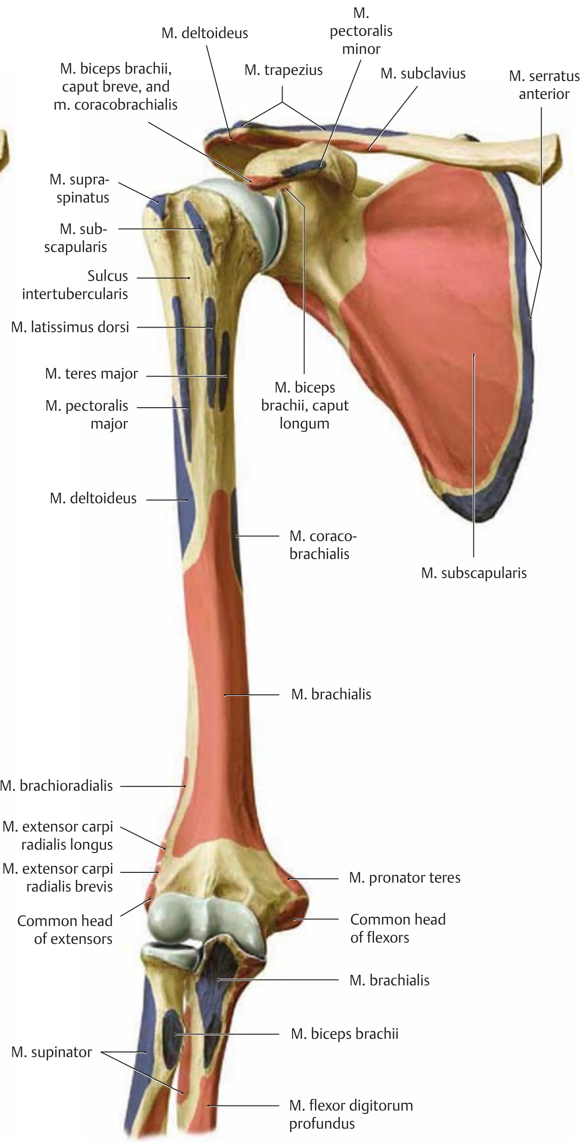
A *Removed:* Thoracic skeleton. *Partially removed:* M. latissimus dorsi and m. serratus anterior.



B *Removed:* M. latissimus dorsi and m. serratus anterior.



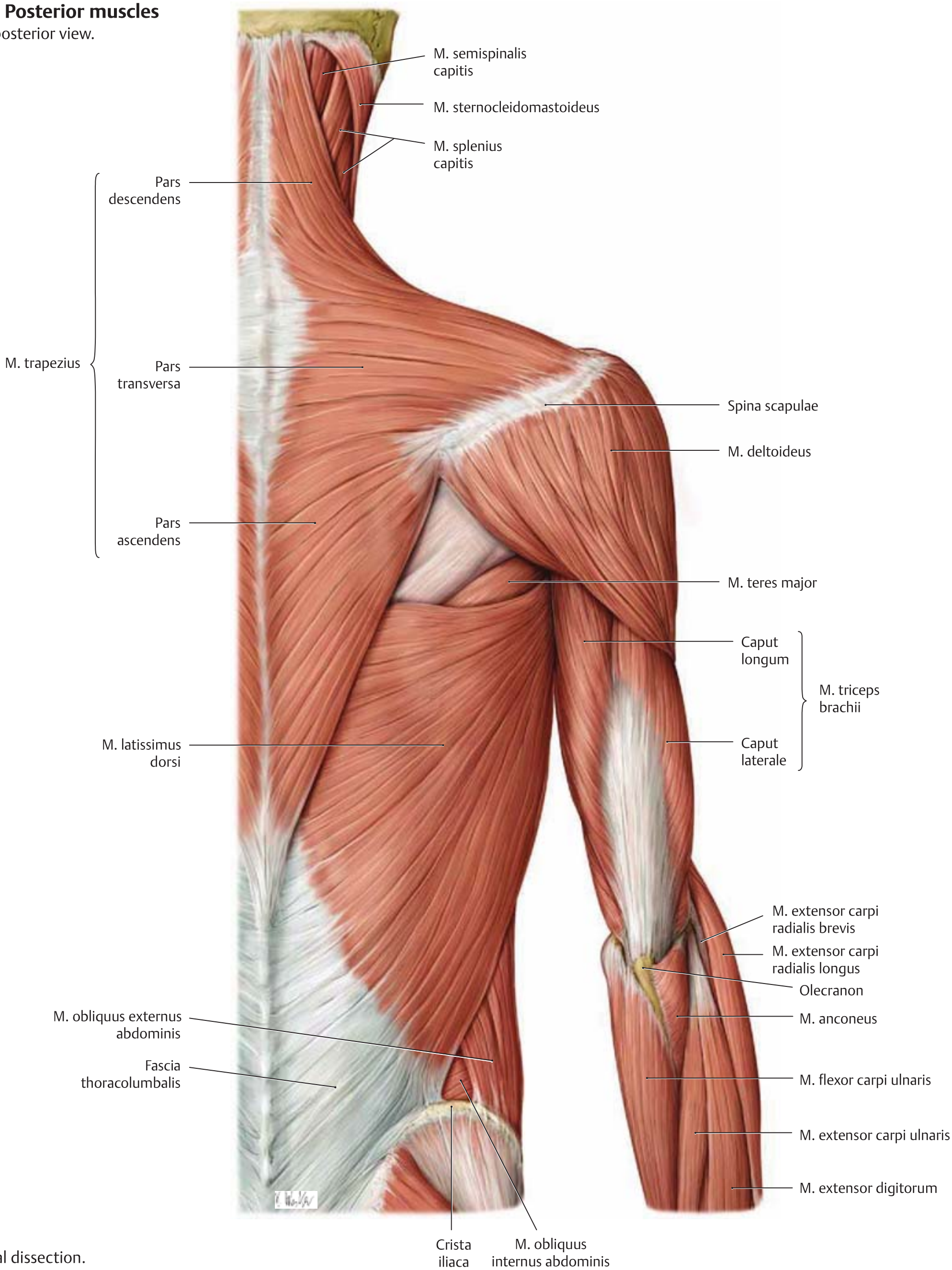
C *Removed:* M. subscapularis and m. supraspinatus.*Partially removed:* M. biceps brachii.



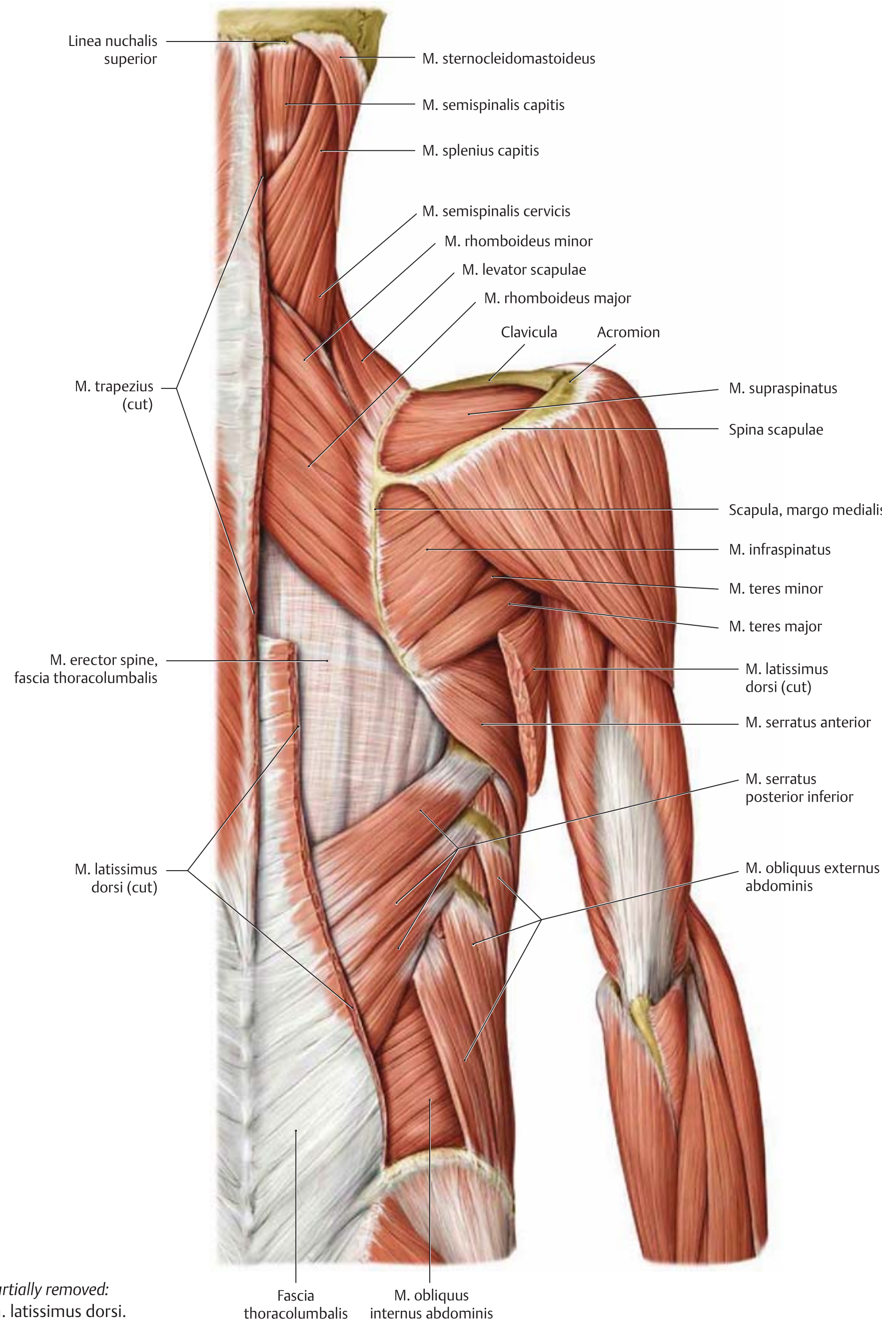
D *Removed:* M. biceps brachii, m. coracobrachialis, and m. teres major.

Posterior Muscles of the Shoulder & Arm (I)

Fig. 19.21 **Posterior muscles**
Right side, posterior view.



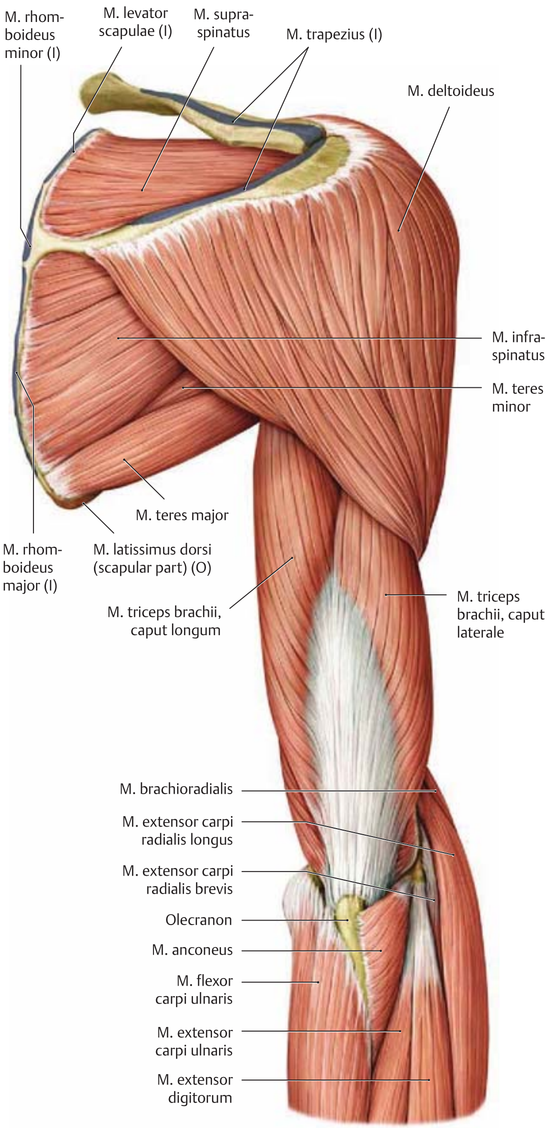
A Superficial dissection.



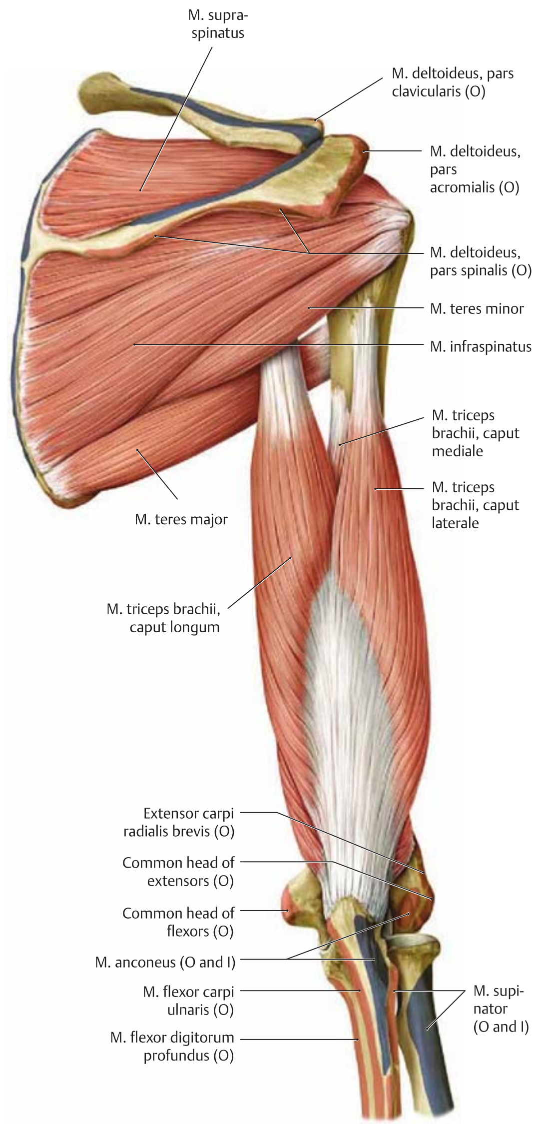
B Deep dissection. *Partially removed:* M. trapezius and m. latissimus dorsi.

Posterior Muscles of the Shoulder & Arm (II)

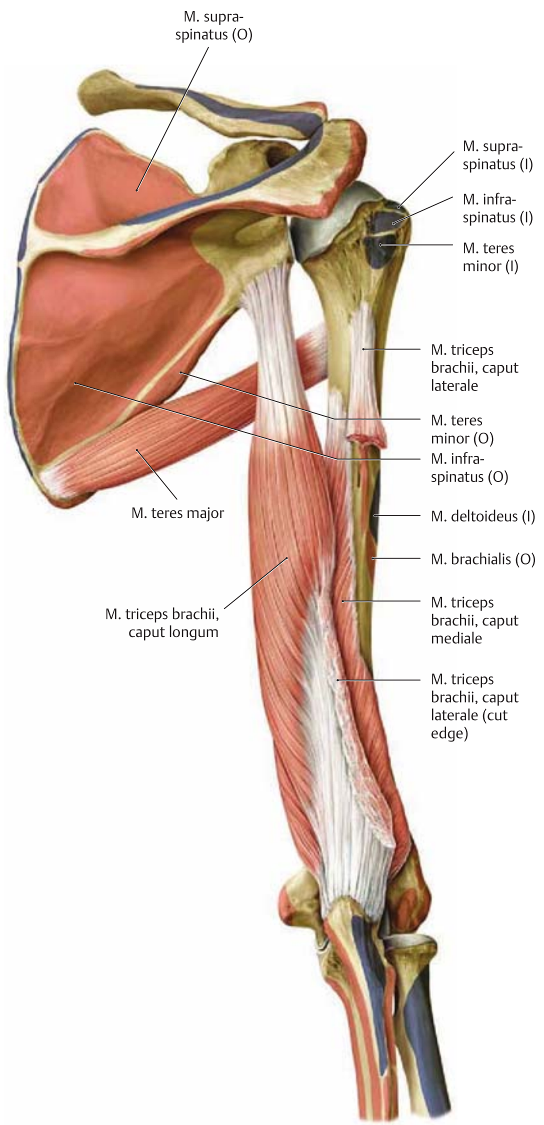
Fig. 19.22 **Posterior dissection**
Right arm, posterior view. Muscle origins (O) are shown in red, insertions (I) in blue.



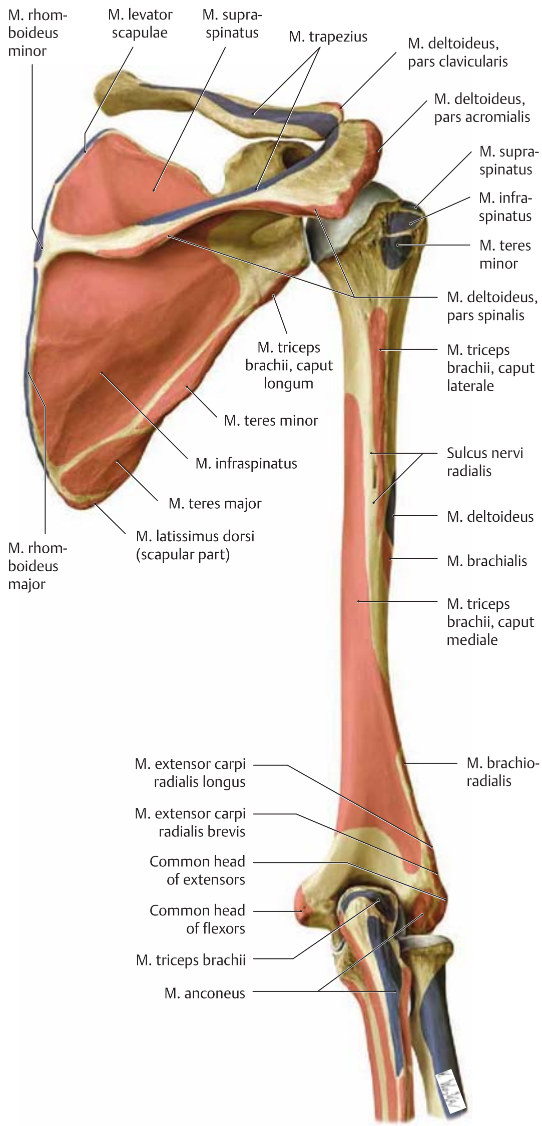
A *Removed:* Mm. rhomboideus major and minor, m. serratus anterior, and m. levator scapulae.



B *Removed:* M. deltoideus and forearm muscles.



C *Removed:* M. supraspinatus, m. infraspinatus, and m. teres minor.
Partially removed: M. triceps brachii.

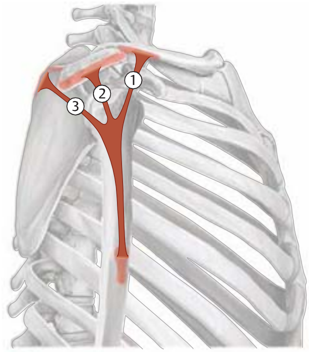


D *Removed:* M. triceps brachii and m. teres major.

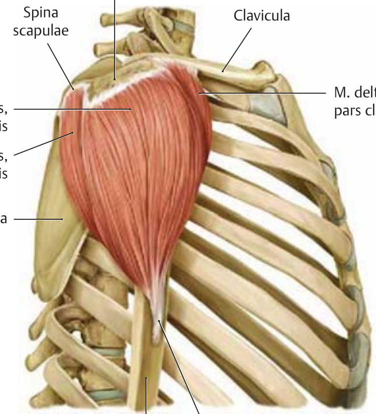
Muscle Facts (I)

The actions of the three parts of m. deltoideus depend on their relationship to the position of the humerus and its axis of motion. At less than 60 degrees, the muscles act as adductors, but at greater than 60 degrees, they act as abductors. As a result, the parts of m. deltoideus can act antagonistically as well as synergistically.

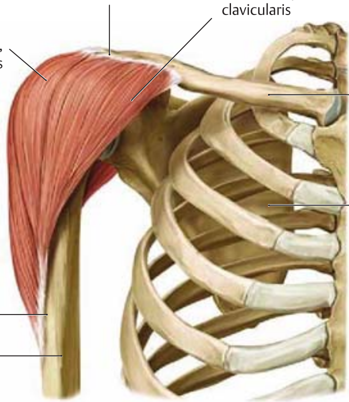
Fig. 19.23 **M. deltoideus**
Right shoulder.



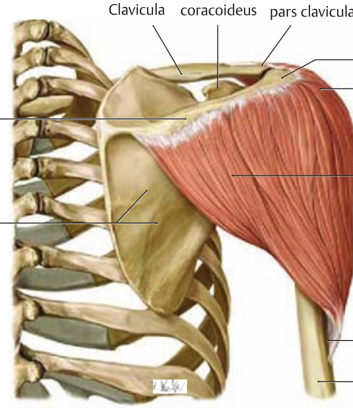
A Parts of the m. deltoideus, right lateral view.



B Right lateral view.



C Anterior view.



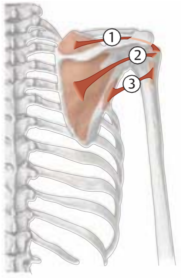
D Posterior view.

Table 19.1 **Parts of the M. deltoideus**

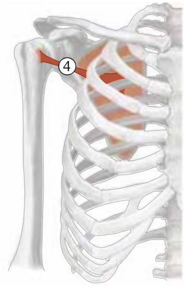
Muscle		Origin	Insertion	Innervation	Action*
M. deltoideus	① Pars clavicularis	Lateral one third of clavicula	Humerus (Tuberositas deltoidea)	N. axillaris (C5, C6)	Flexion, internal rotation, adduction
	② Pars acromialis	Acromion			Abduction
	③ Pars spinalis	Spina scapulae			Extension, external rotation, adduction

* Between 60 and 90 degrees of abduction, Pars clavicularis and Pars spinalis assist the Pars acromialis with abduction.

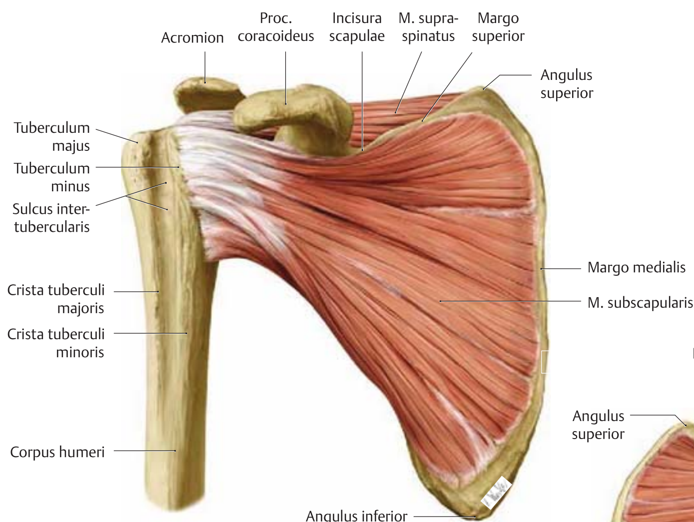
Fig. 19.24 **Rotator cuff**
Right shoulder. The rotator cuff consists of four muscles: M. supraspinatus, m. infraspinatus, m. teres minor, and m. subscapularis.



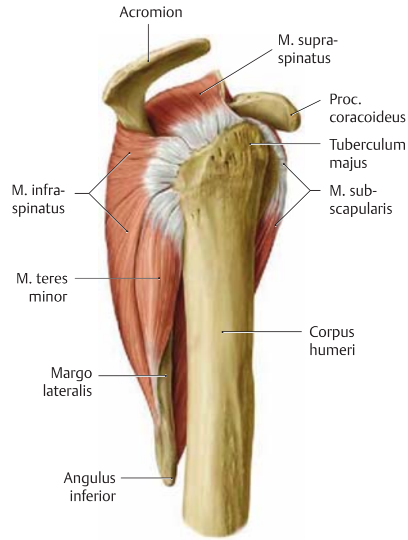
A Posterior view.



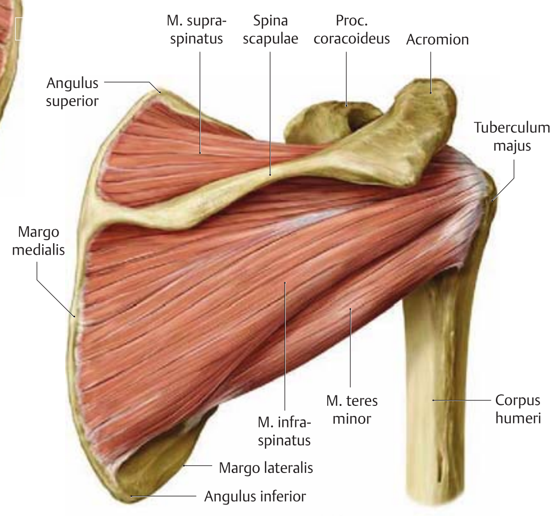
B Anterior view.



C Anterior view.



D Lateral view.



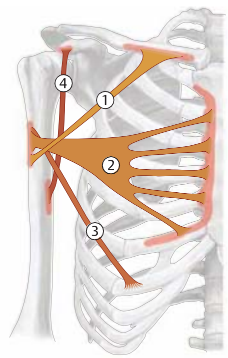
E Posterior view.

Table 19.2 **Muscles of the rotator cuff**

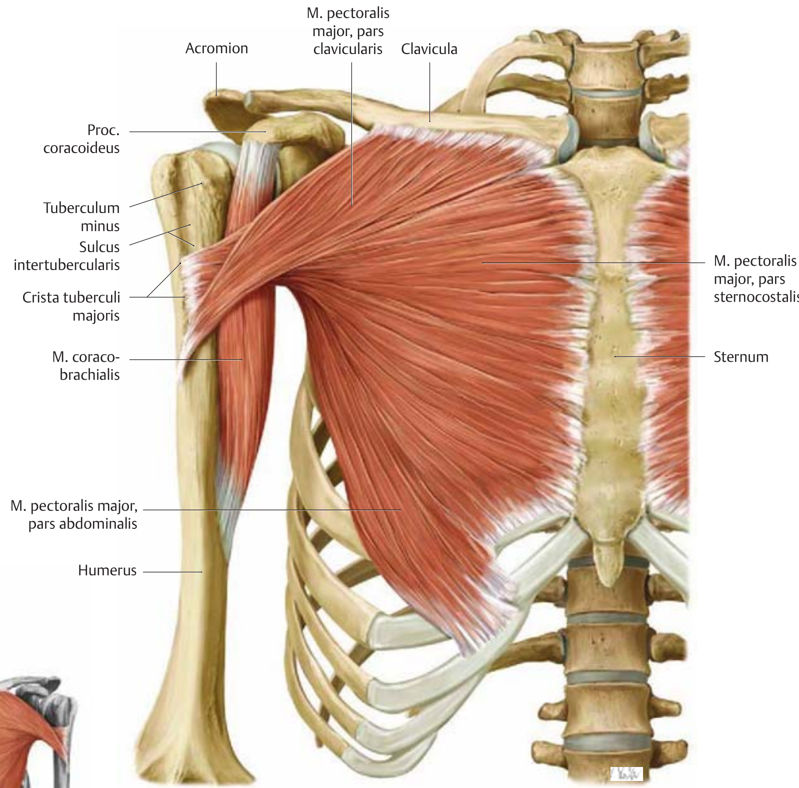
Muscle	Origin		Insertion		Innervation	Action
① M. supraspinatus	Scapula	Fossa supraspinata scapulae	Humerus	Tuberculum majus humeri	N. suprascapularis (C4–C6)	Abduction
② M. infraspinatus		Fossa infraspinata scapulae				External rotation
③ M. teres minor		Margo lateralis scapulae			N. axillaris (C5, C6)	External rotation, weak adduction
④ M. subscapularis		Fossa subscapularis scapulae		Tuberculum minus humeri	N. subscapularis (C5, C6)	Internal rotation

Muscle Facts (II)

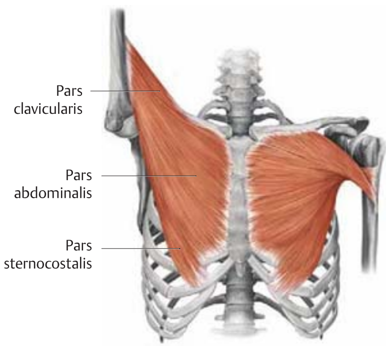
Fig. 19.25 **M. pectoralis major and m. coracobrachialis**
Anterior view.



A Schematic.



C M. pectoralis major and m. coracobrachialis.

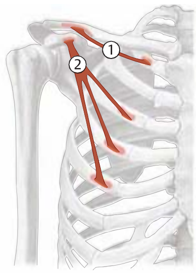


B M. pectoralis major in neutral position (left) and elevation (right).

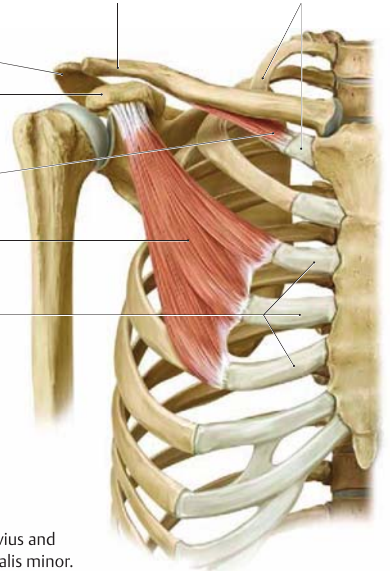
Table 19.3 **M. pectoralis major and M. coracobrachialis**

Muscle		Origin	Insertion	Innervation	Action
M. pectoralis major	① Pars clavicularis	Clavicula (medial half)	Humerus (crista tuberculi majoris humeri)	Nn. pectorales mediales et laterales (C5–T1)	Entire muscle: adduction, internal rotation Pars clavicularis and pars sternocostalis: flexion; assist in respiration when shoulder is fixed
	② Pars sternocostalis	Sternum and cartilagines costales 1–6			
	③ Pars abdominalis	Rectus sheath (anterior layer)			
④ M. coracobrachialis		Scapula (proc. coracoideus scapulae)	Humerus (crista tuberculis minoris)	N. musculo-cutaneous (C6, C7)	Flexion, adduction, internal rotation

Fig. 19.26 **M. subclavius and m. pectoralis minor**
Right side, anterior view.

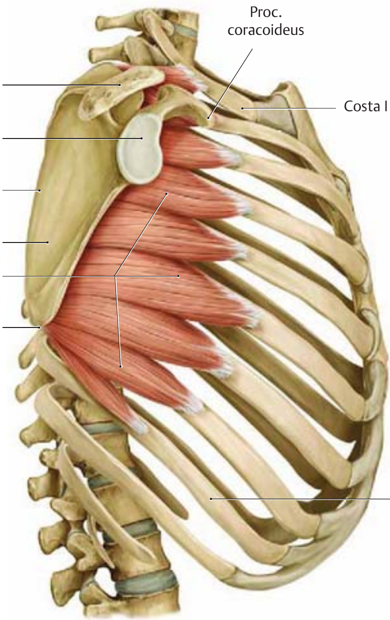


A Schematic.

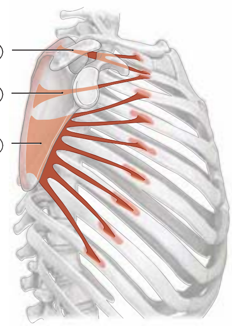


B M. subclavius and m. pectoralis minor.

Fig. 19.27 **M. serratus anterior**
Right lateral view.



A M. serratus anterior.



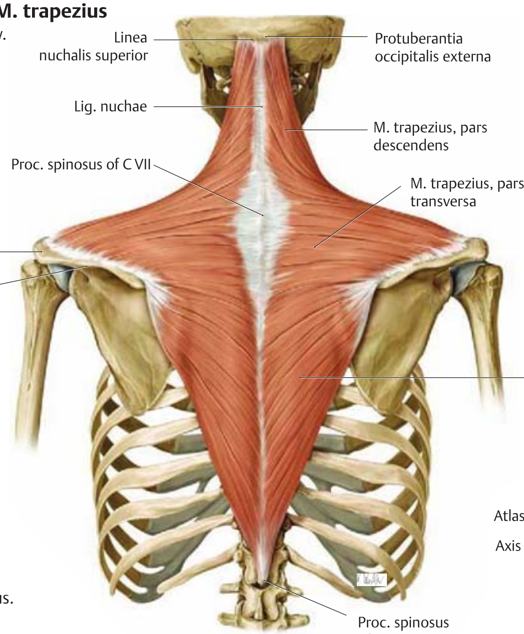
B Schematic.

Table 19.4	**M. subclavius, m. pectoralis minor, and m. serratus anterior**				
Muscle		**Origin**	**Insertion**	**Innervation**	**Action**
① M. subclavius		Costa I	Clavicula (inferior surface)	N. subclavius (C5, C6)	Steadies the clavicula in the articulatio sternoclavicularis
② M. pectoralis minor		Costa III–V	Proc. coracoideus scapulae	Nn. pectorales mediales et laterales	Draws scapula downward, causing inferior angle to move posteromedially; rotates glenoid inferiorly; assists in respiration
M. serratus anterior	③ Pars superior	Costa I–IX	Scapula (margo medialis)	N. thoracicus longus (C5–C7)	Pars superior: lowers the raised arm
	④ Pars intermedia				Entire muscle: draws scapula laterally forward; elevates ribs when shoulder is fixed
	⑤ Pars inferior				Pars inferior: rotates scapula laterally

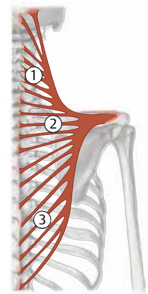
Muscle Facts (III)

Fig. 19.28 M. trapezius

Posterior view.



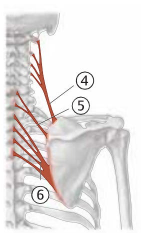
A M. trapezius.



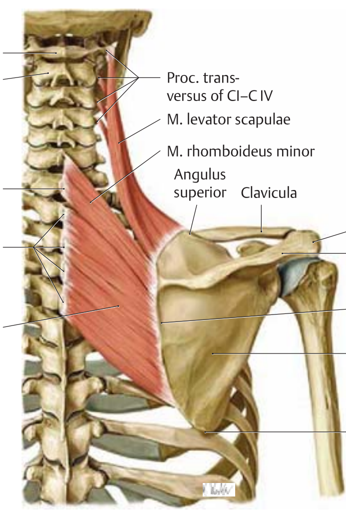
B Schematic.

Fig. 19.29 M. levator scapulae with mm. rhomboideus major and minor

Right side, posterior view.



A Schematic.



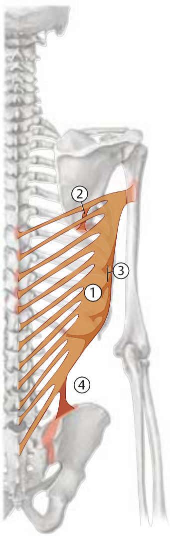
B M. levator scapulae with mm. rhomboideus major and minor.

Table 19.5 M. trapezius, m. levator scapulae, and m. rhomboideus major and minor

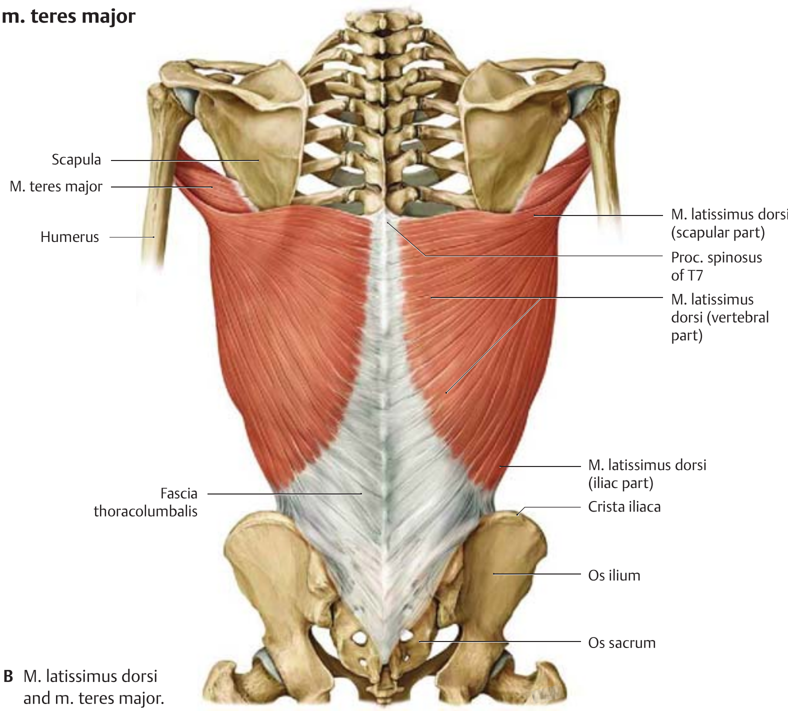
Muscle		Origin	Insertion	Innervation	Action
M. trapezius	① Pars descendens	Protuberantia occipitalis ext.; procc. spinosi of C I–C VII	Clavicula (lateral one third)	N. accessorius (CN XI); Plexus cervicalis (C3–C4)	Draws scapula obliquely upward; rotates cavitas glenoidalis superiorly; tilts head to same side and rotates it to opposite
	② Pars transversa	Aponeurosis at T I–T IV Proc. spinosus	Acromion		Draws scapula medially
	③ Pars ascendens	Procc. spinosi of T V–T XII	Spina scapulae		Draws scapula medially downward
					Entire muscle: steadies scapula on thorax
④ M. levator scapulae		Procc. transversi of C I–C IV	Angulus superior scapulae	N. dorsalis scapulae (C4–C5)	Draws scapula medially upward while moving angulus inferior medially; inclines neck to same side
⑤ M. rhomboideus minor		Procc. spinosi of C VI, C VII	Medial border of scapula above (minor) and below (major) spina scapulae		Steadies scapula; draws scapula medially upward
⑥ M. rhomboideus major		Procc. spinosi of T I–T IV vertebrae			

CN = cranial nerve.

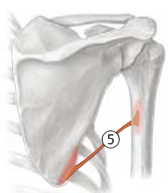
Fig. 19.30 **M. latissimus dorsi and m. teres major**
Posterior view.



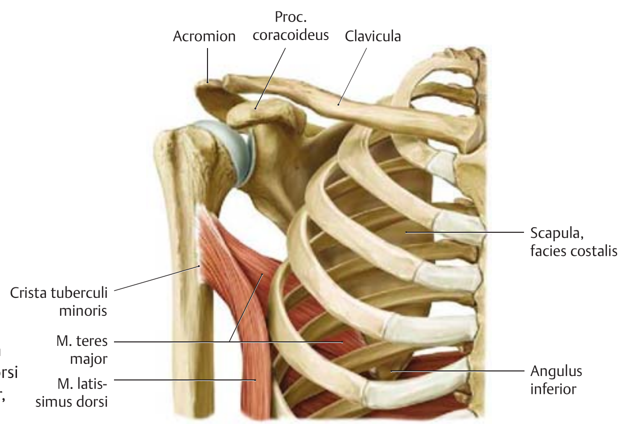
A M. latissimus dorsi.



B M. latissimus dorsi and m. teres major.



C M. teres major.



D Common insertion of m. latissimus dorsi and m. teres major, anterior view.

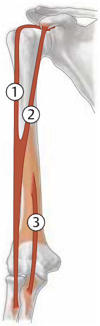
Table 19.6 M. latissimus dorsi and M. teres major

Muscle		Origin	Insertion	Innervation	Action
M. latissimus dorsi	① Pars vertebralis	Procc. spinosi of T VII–T XII vertebrae thoracicae; fascia thoracolumbalis	Humerus (crista tuberculis minoris)	N. thoracodorsalis (C6–C8)	Internal rotation, adduction, extension, respiration ("cough muscle")
	② Pars scapularis	Angulus inferior scapulae			
	③ Pars costalis	Costa IX–XII			
	④ Pars iliaca	Crista iliaca (posterior one third)			
⑤ M. teres major		Angulus inferior scapulae		N. subscapularis (C5–C7)	Internal rotation, adduction, extension

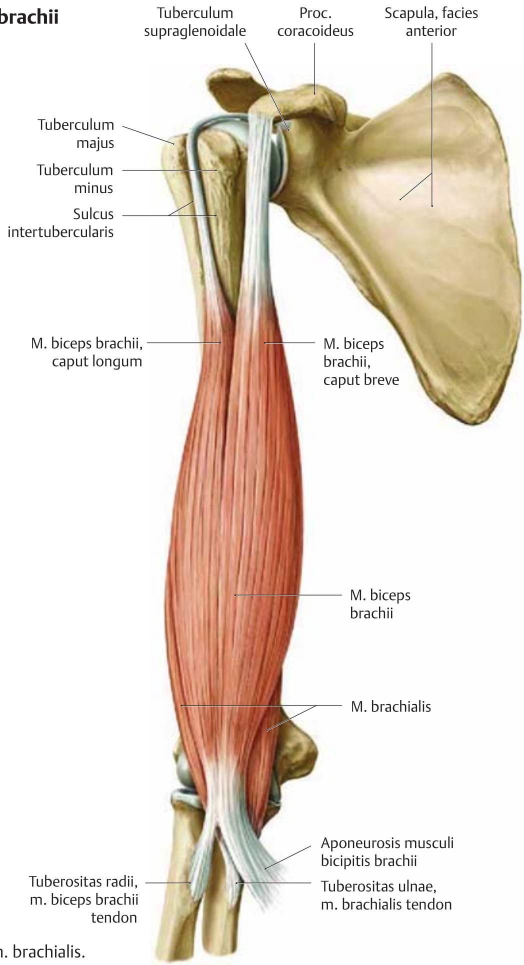
Muscle Facts (IV)

The anterior and posterior muscles of the arm may be classified respectively as flexors and extensors relative to the movement of the elbow joint. Although m. coracobrachialis is topographically part of the anterior compartment, it is functionally grouped with the muscles of the shoulder (see p. 274).

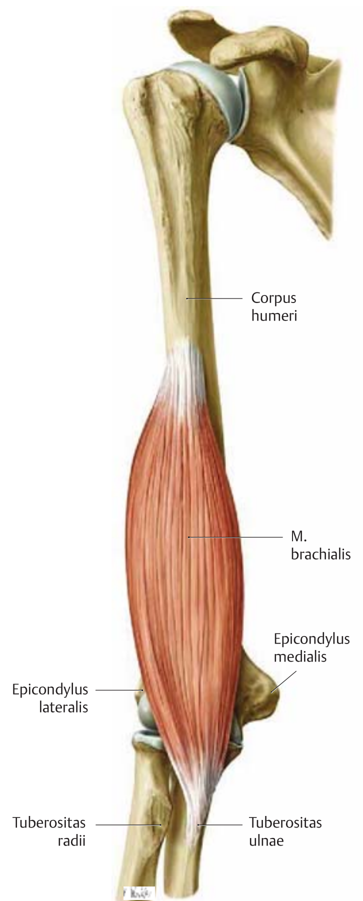
Fig. 19.31 **M. biceps brachii and m. brachialis**
Right arm, anterior view.



A Schematic.



B M. biceps brachii and m. brachialis.



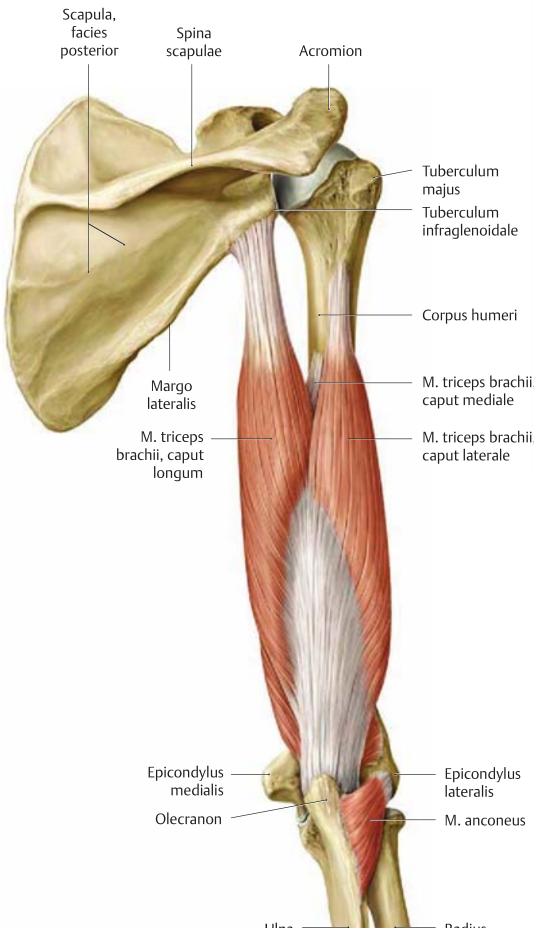
C M. brachialis.

Table 19.7 **Anterior group: M. biceps brachii and M. brachialis**

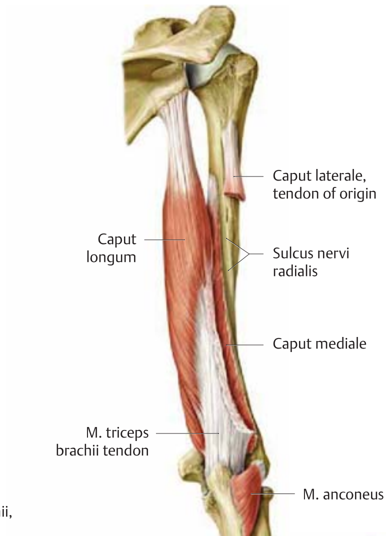
Muscle		Origin	Insertion	Innervation	Action
M. biceps brachii	① Caput longum	Tuberculum supraglenoidale scapulae	Tuberositas radii	N. musculocutaneous (C5–C6)	Articulatio cubiti: flexion; supination* Shoulder joint: flexion; stabilization of humeral head during m. deltoideus contraction; abduction and internal rotation of the humerus
	② Caput breve	Proc. scapulae			
③ M. brachialis		Humerus (distal half of anterior surface)	Tuberositas ulnae	N. musculocutaneous (C5–C6) and N. radialis (C7, minor)	Flexion at the Articulatio cubiti

* *Note:* When the elbow is flexed, the M. biceps brachii acts as a powerful supinator because the lever arm is almost perpendicular to the axis of pronation/supination.

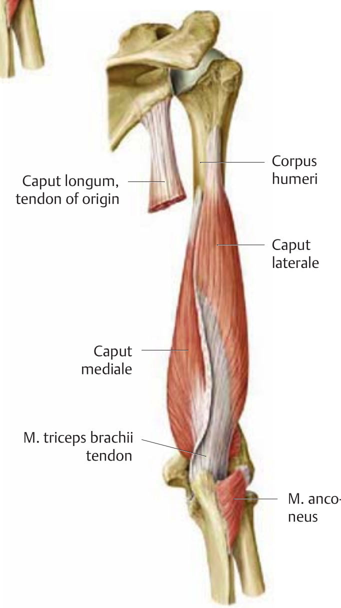
Fig. 19.32 **M. triceps brachii and m. anconeus**
Right arm, posterior view.



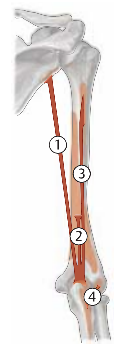
A M. triceps brachii and m. anconeus.



B *Partially removed:* Caput laterale of m. triceps brachii.



C *Partially removed:* Caput longum of m. triceps brachii.



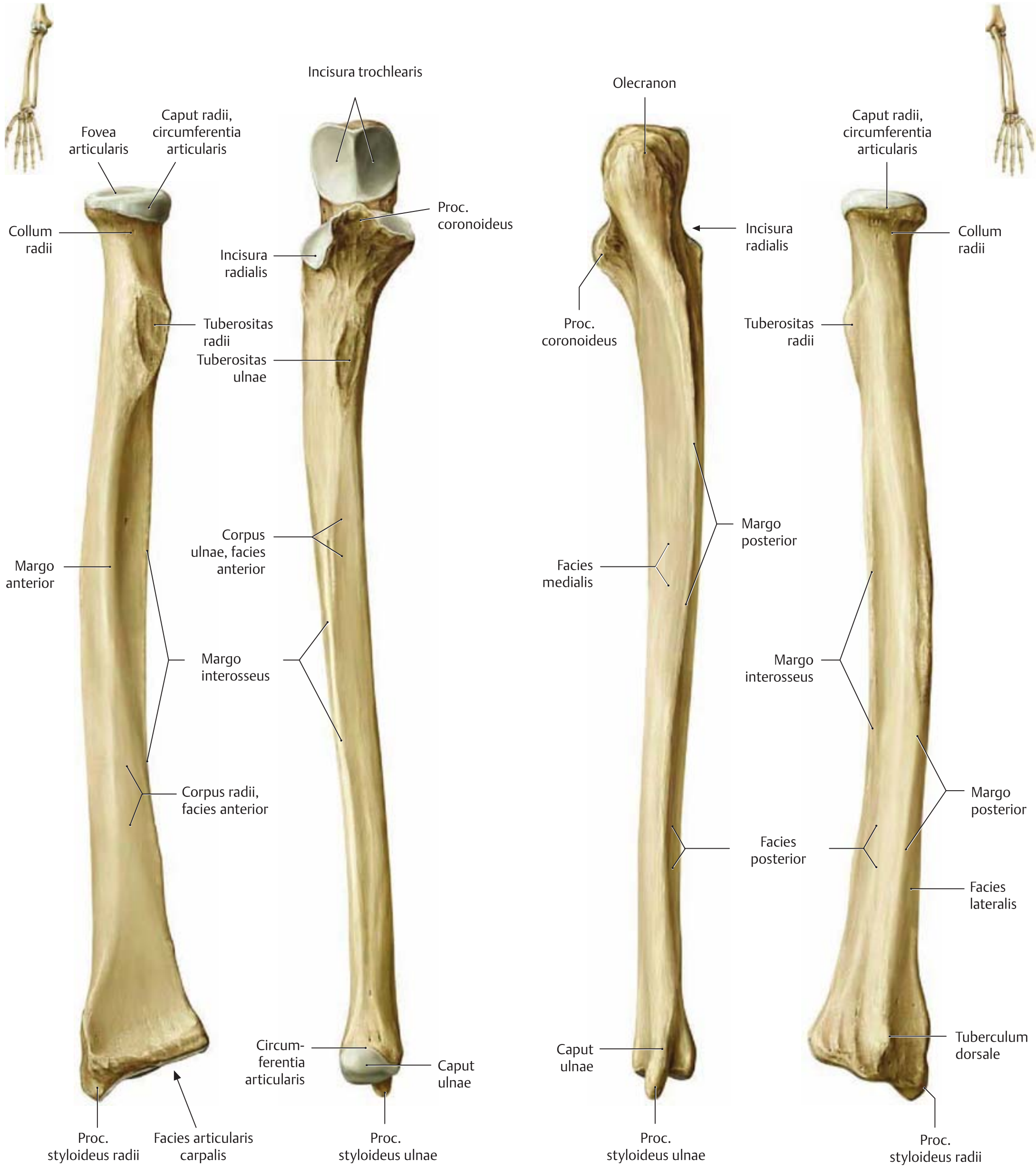
D Schematic.

Table 19.8 Posterior group: M. triceps brachii and M. anconeus

Muscle		Origin	Insertion	Innervation	Action
M. triceps brachii	① Caput longum	Tuberculum infraglenoidale scapulae	Olecranon ulnae	N. radialis (C6–C8)	Articulatio cubiti: extension Articulatio humeri, Caput longum: extension and adduction
	② Caput mediale	Posterior humerus, distal to sulcus radialis; septum intermuscularis medialis			
	③ Caput laterale	Posterior humerus, proximal to sulcus radialis; lateral to septum intermuscularis			
④ M. anconeus		Epicondylus lateralis humeri (variance: posterior joint capsule)	Olecranon ulnae (radial surface)		Extends the elbow and tightens its joint

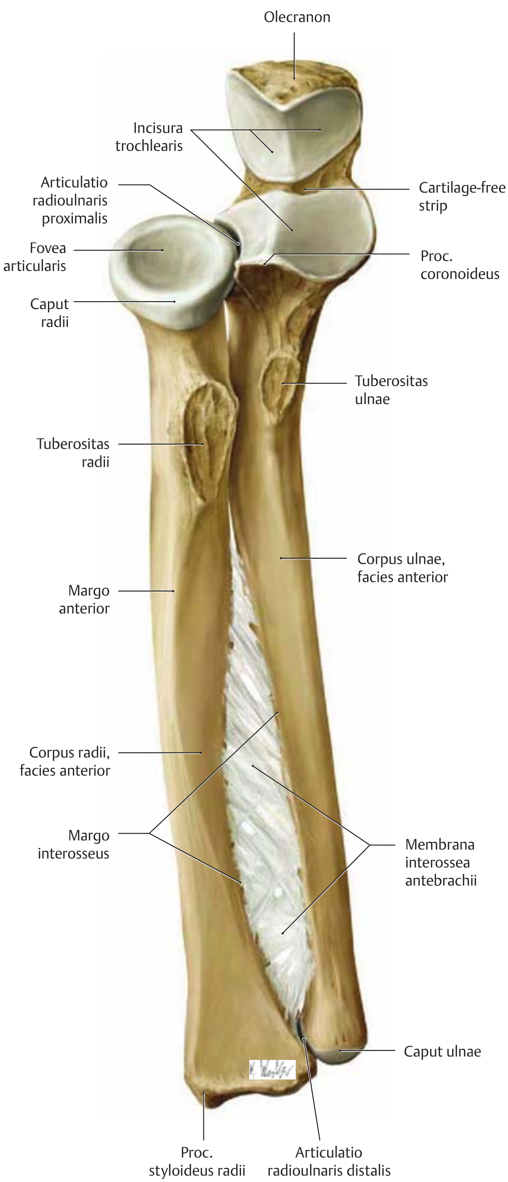
Radius & Ulna

Fig. 20.1 **Radius and ulna**
Right forearm.

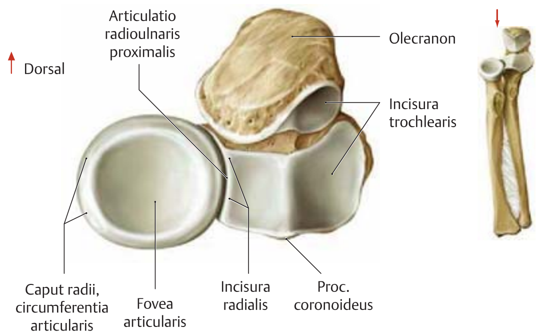


A Anterior view.

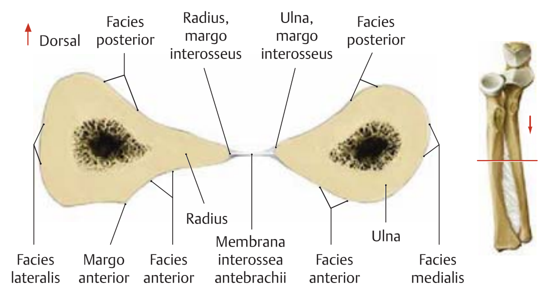
B Posterior view.



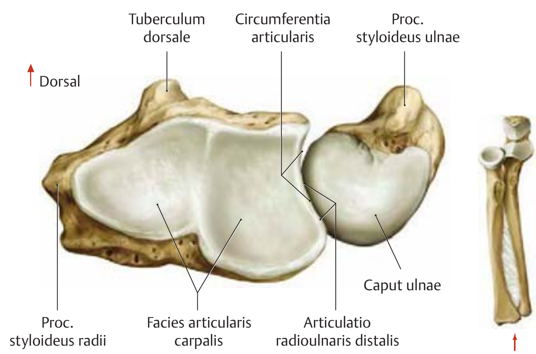
C Anterosuperior view.



D Proximal view.



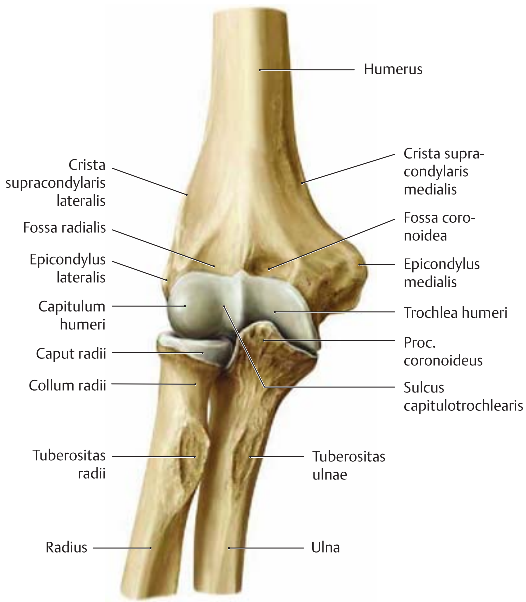
E Transverse section, proximal view.



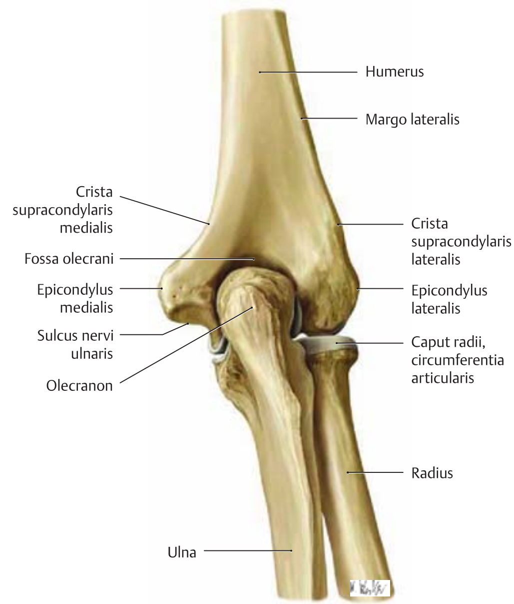
F Distal view.

Articulatio Cubiti

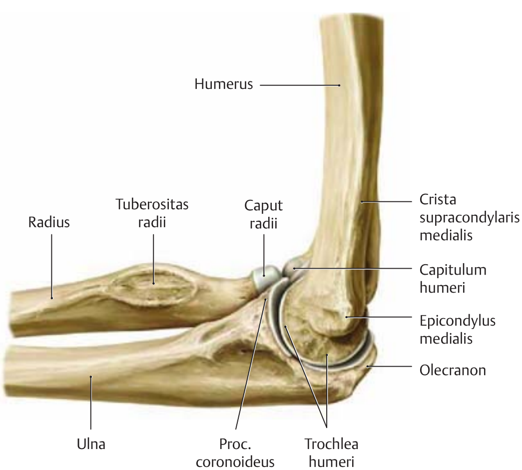
Fig. 20.2 **Articulatio cubiti**
Right limb. The elbow consists of three articulations between the humerus, ulna, and radius: articulatio humeroulnaris, articulatio humeroradialis, and articulatio radioulnaris proximalis.



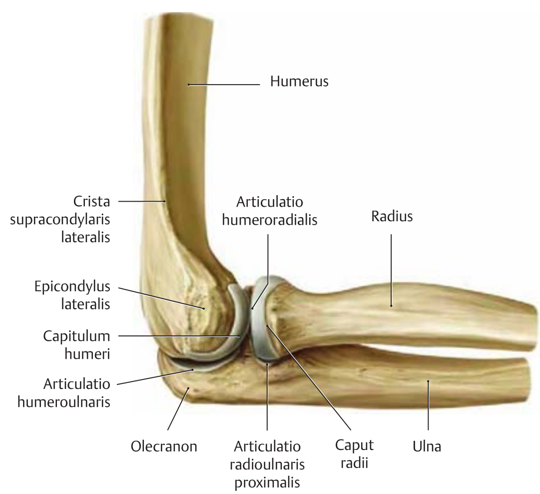
A Anterior view.



B Posterior view.



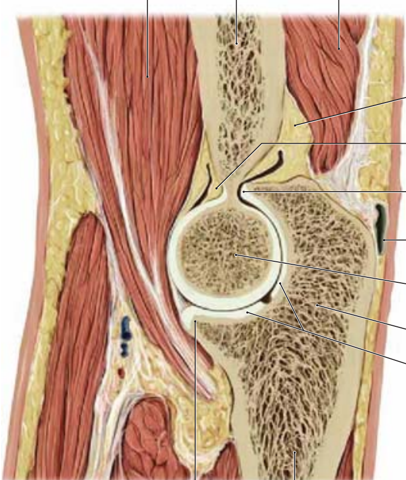
C Medial view.



D Lateral view.

Fig. 20.3 **MRI of articulatio cubiti**
Sagittal section.

Fig. 20.4 **Articulatio humeroulnaris**
Sagittal section through articulatio humeroulnaris, medial view.



Clinical

Assessing elbow injuries
The fat pads between the fibrous capsule and synovial membrane are part of the normal anatomy of the elbow joint. The anterior pad is most readily seen on a sagittal MRI while the posterior pad is often hidden within the bony fossa (Fig. 20.3). With an effusion of the joint space, the inferior edge of the anterior pad appears concave as it gets pushed superiorly by the intra-articular fluid. This causes the pad to resemble the shape of a ship's sail, thus creating a characteristic "sail sign." The alignment of the prominences in the elbow also aids in the identification of fractures and dislocations.

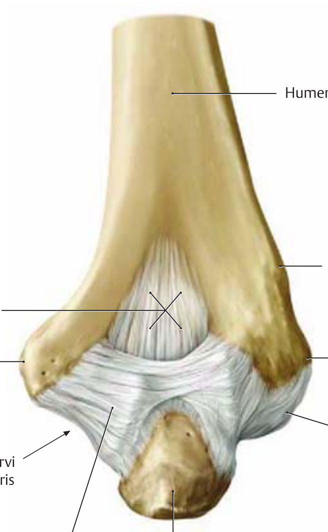
A Posterior view of extended elbow: The epicondyles and olecranon lie in a straight line.

B Lateral view of flexed elbow: The epicondyles and olecranon lie in a straight line.

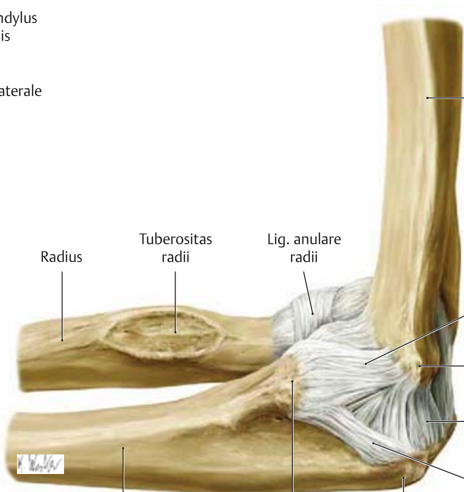
C Posterior view of flexed elbow: The two epicondyles and the tip of the olecranon form an equilateral triangle. Fractures and dislocations alter the shape of the triangle.

Ligaments of Articulatio Cubiti

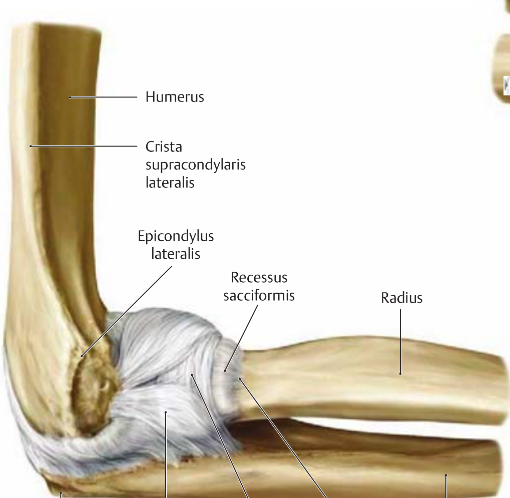
Fig. 20.5 **Ligaments of articulatio cubiti**
Right elbow in flexion.



A Posterior view.



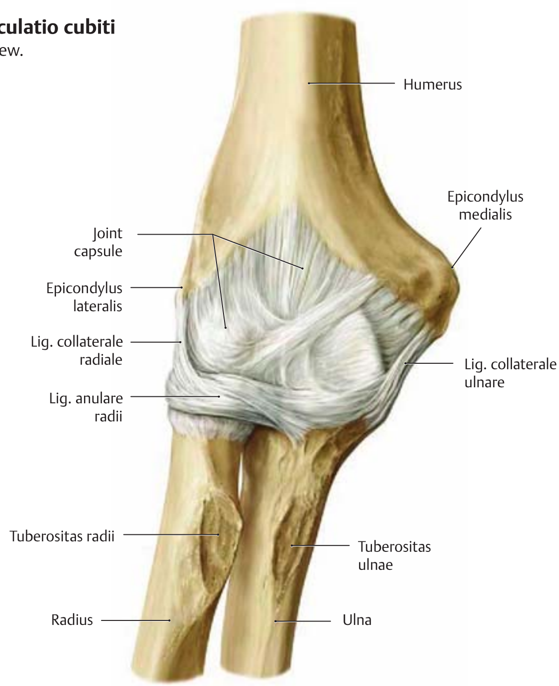
B Medial view.



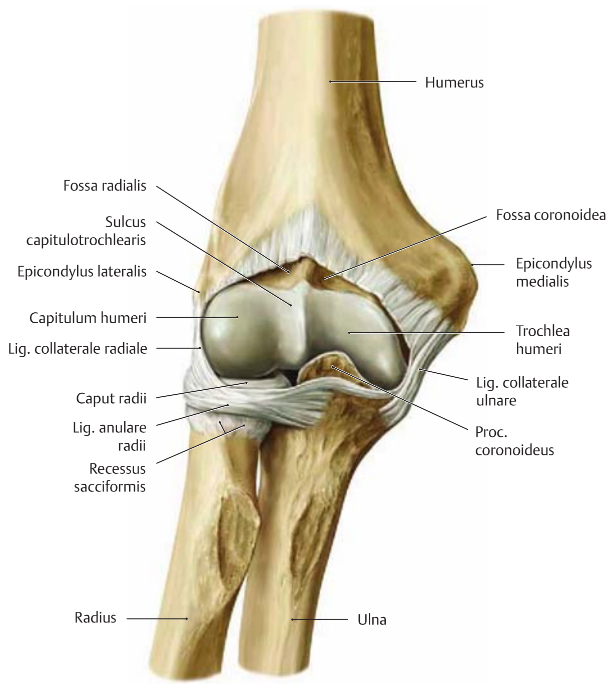
C Lateral view.

Table 20.1	**Joints and ligaments of articulatio cubiti**		
Joint	**Articulating surfaces**		**Ligament**
Articulatio humeroulnaris	Trochlea humeri	Incisura trochlearis ulnae	Lig. collaterale ulnare
Articulatio humeroradialis	Capitulum humeri	Fovea capitis radii	Lig. collaterale radiale
Articulatio radio-ulnaris distalis	Circumferentia articularis caput ulnae	Incisura ulnaris radii	Lig. anulare radii

Fig. 20.6 **Joint capsule of articulatio cubiti**
Right elbow in extension, anterior view.



A Intact joint capsule.



B Windowed joint capsule.

Radioulnar Joints

Articulatio radioulnaris proximalis and articulatio radioulnaris distalis function together to enable pronation and supination movements of the hand. The joints are functionally linked by membrana interossea antebrachii. The axis for pronation and supination runs obliquely from the center of capitulum humeri through the center of fovea articularis radii down to processus styloideus ulnae.

***Fig. 20.7* Supination**
Right forearm, anterior view.

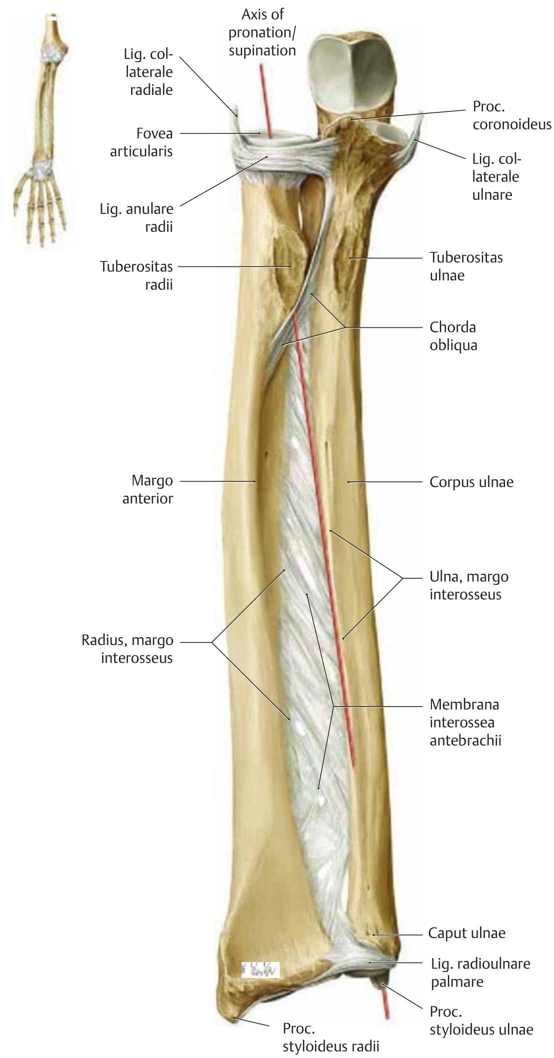
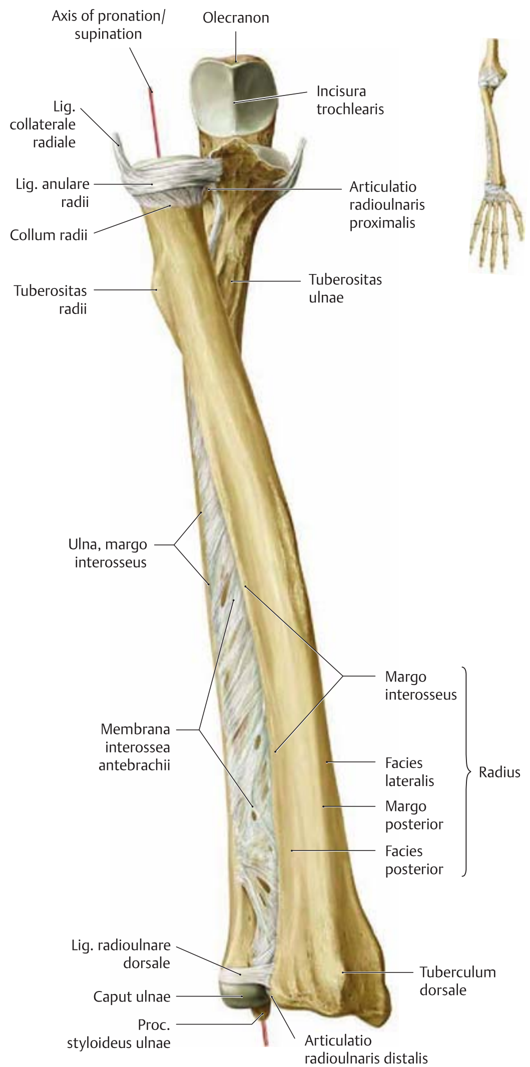


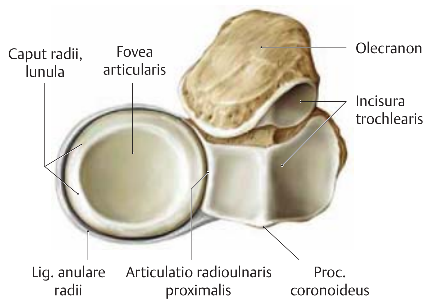
***Fig. 20.8* Pronation**
Right forearm, anterior view.



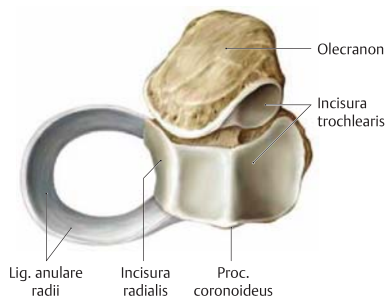
Clinical

Subluxation of caput radii ("nursemaid's elbow")
When small children are abruptly pulled up by their arm, the immature caput radii can dislocate from the lig. anulare radii, resulting in painful pronation.

Fig. 20.9 Articulatio radioulnaris proximalis
Right elbow, proximal (superior) view.



A Proximal articular surfaces of radius and ulna.



B Radius removed.

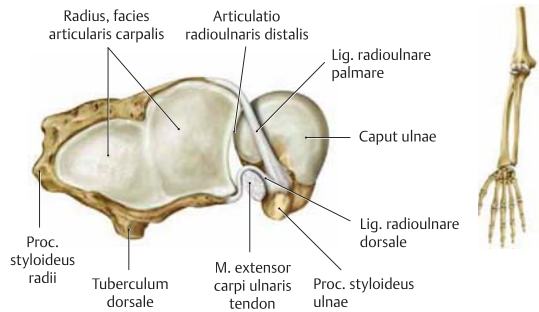
Clinical

Radius fracture
Falls onto the outstretched arm often result in fractures of the distal radius. In a "Colles' fracture," the distal fragment is tilted dorsally.

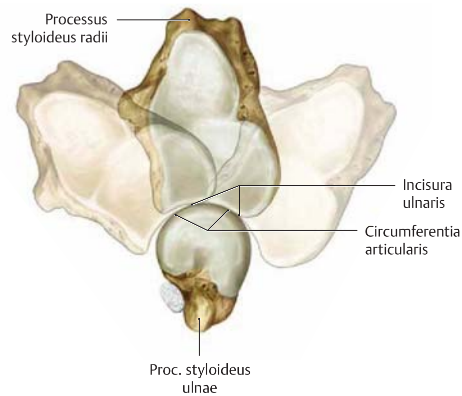
A

B

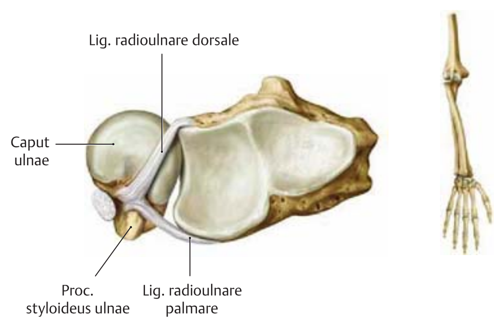
Fig. 20.10 Rotation of articulatio radioulnaris distalis
Right forearm, distal view of articular surfaces of radius and ulna. The ligg. radioulnare dorsale and palmare stabilize articulatio radioulnaris distalis.



A Supination.



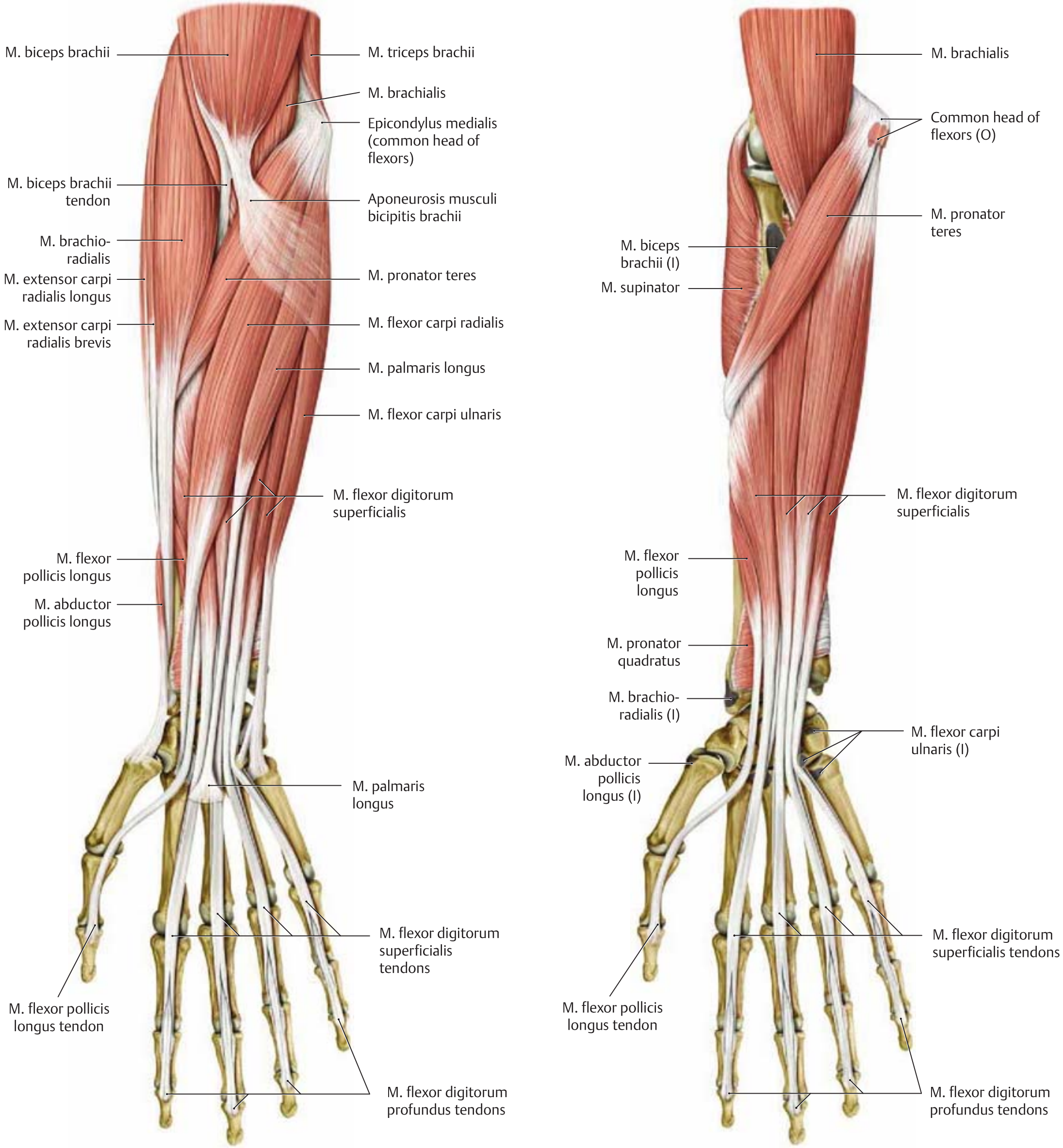
B Semipronation.



C Pronation.

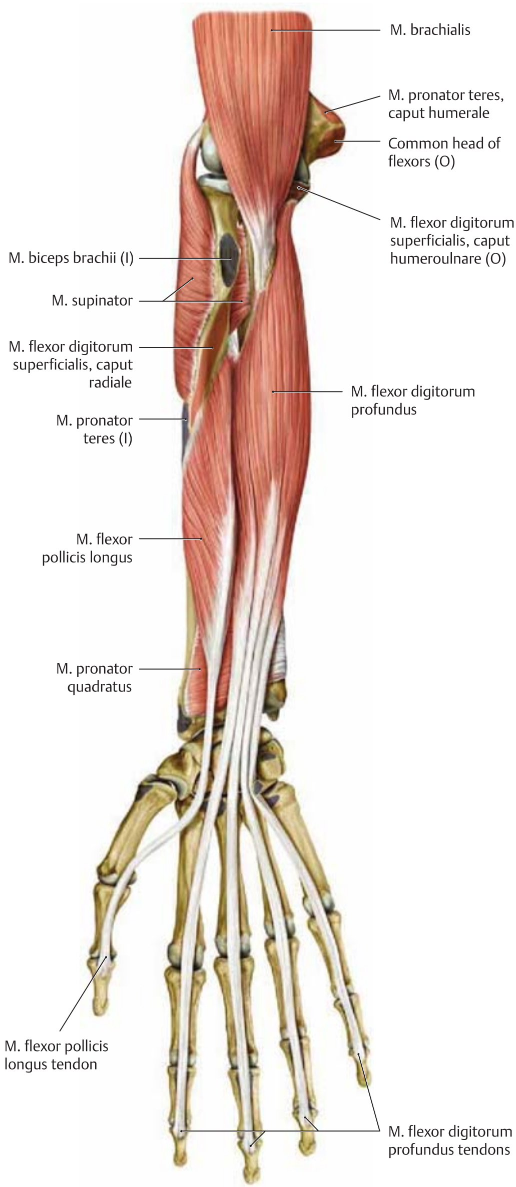
Muscles of the Forearm (I)

Fig. 20.11 **Anterior muscles**
Right forearm, anterior view. Muscle origins (O) are shown in red, insertions (I) in blue.

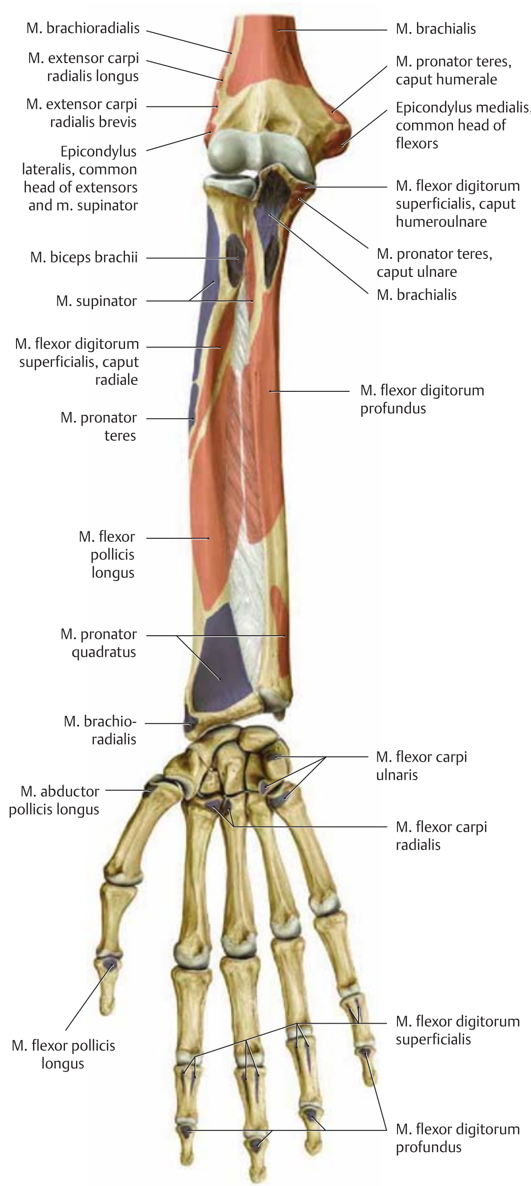


A Superficial flexors and radialis group.

B *Removed:* Radialis group (m. brachioradialis, m. extensor carpi radialis longus, and m. extensor carpi radialis brevis), m. flexor carpi radialis, m. flexor carpi ulnaris, m. abductor pollicis longus, m. palmaris longus, and m. biceps brachii.



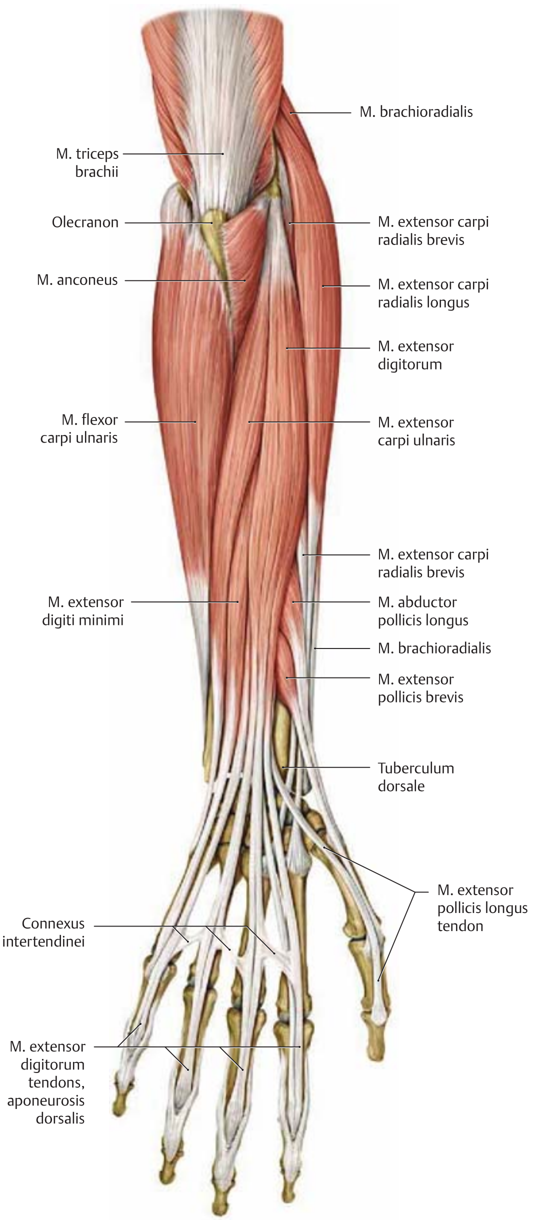
C *Removed:* M. pronator teres and m. flexor digitorum superficialis.



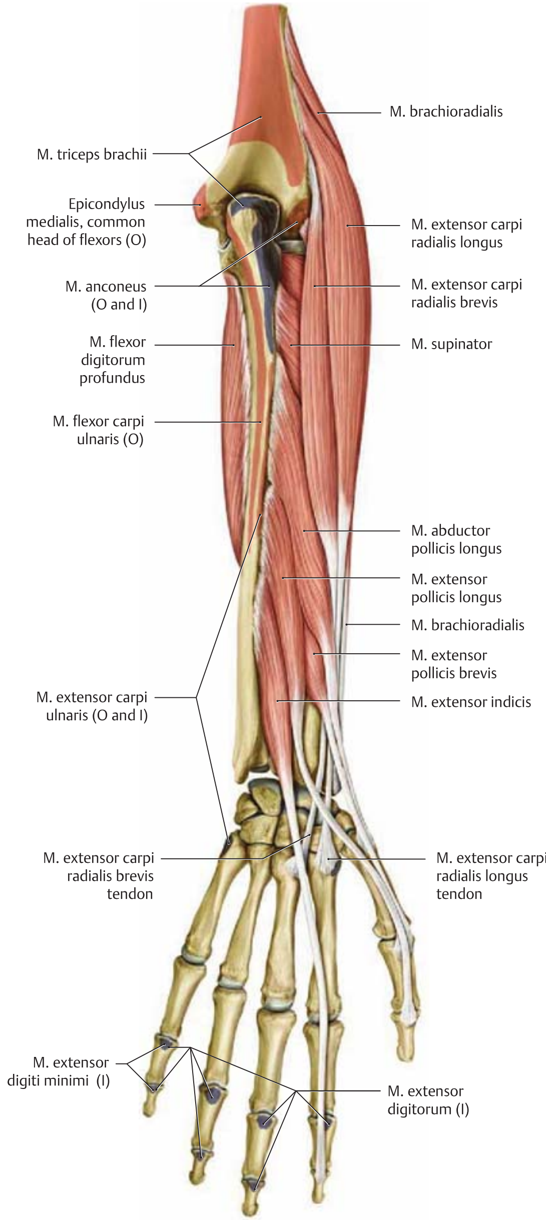
D *Removed:* M. brachialis, m. supinator, m. pronator quadratus, and deep flexors.

Muscles of the Forearm (II)

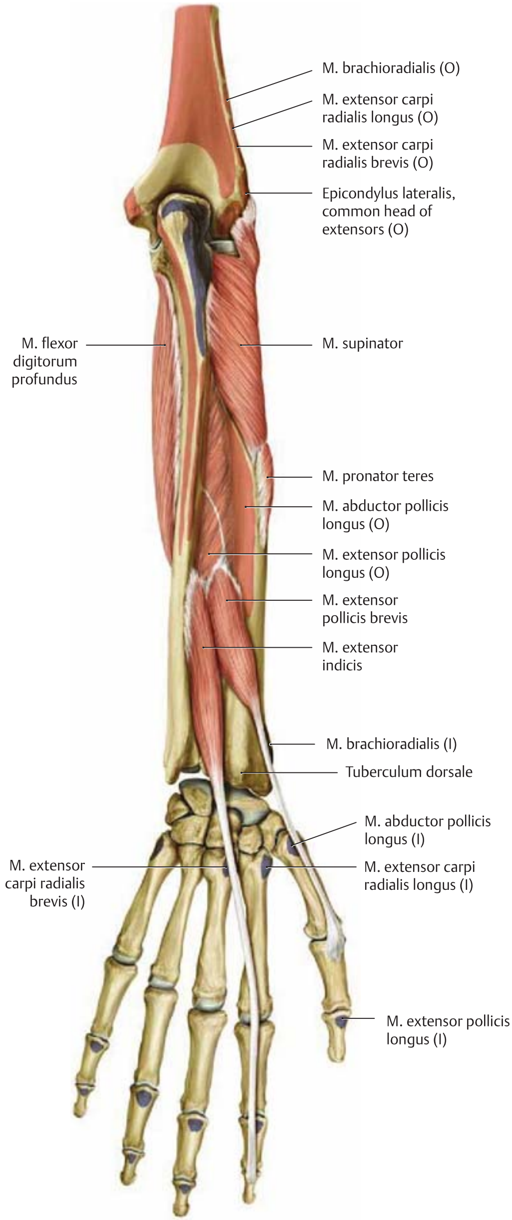
Fig. 20.12 **Posterior muscles**
Right forearm, posterior view. Muscle origins (O) are shown in red, insertions (I) in blue.



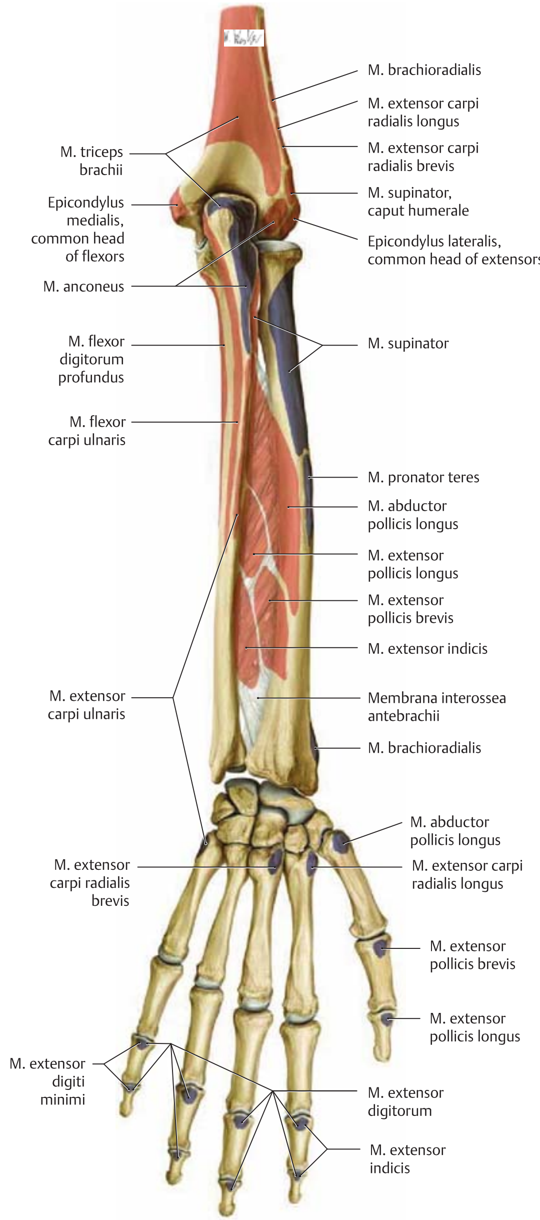
A Superficial extensors and radialis group.



B *Removed:* M. triceps brachii, m. anconeus, m. flexor carpi ulnaris, m. extensor carpi ulnaris, and m. extensor digitorum.



C *Removed:* M. abductor pollicis longus, m. extensor pollicis longus, and radialis group.



D *Removed:* M. flexor digitorum profundus, m. supinator, m. extensor pollicis brevis, and m. extensor indicis.

Muscle Facts (I)

Fig. 20.13 **Anterior compartment**
Right forearm, anterior view.

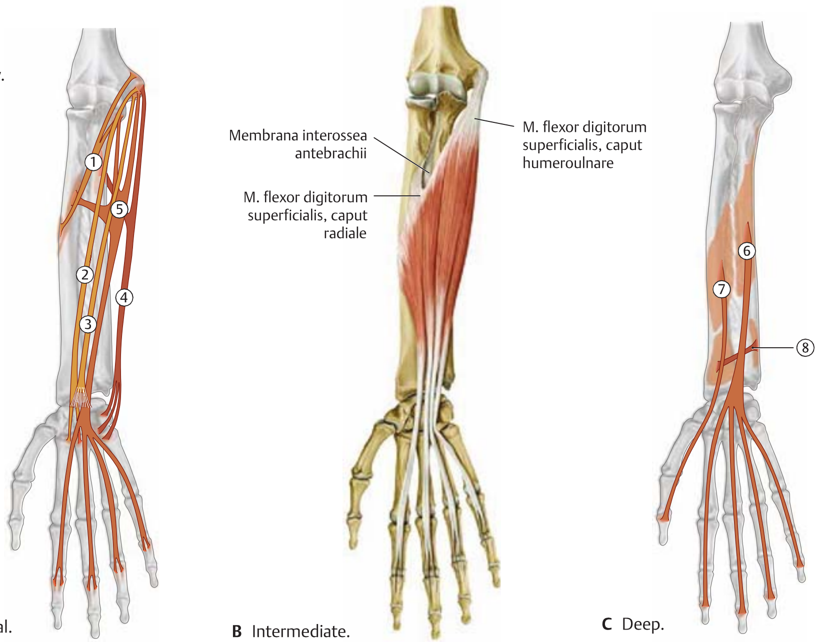


Table 20.2 **Anterior compartment of the forearm**

Muscle	Origin	Insertion	Innervation	Action
Superficial group				
① M. pronator teres	Caput humerale: Epicondylus medialis humeri Caput ulnare: Proc. coronoideus ulnae	Lateral radius (distal to supinator insertion)	N. medianus (C6, C7)	Art. cubiti: weak flexor Forearm: pronation
② M. flexor carpi radialis	Epicondylus medialis humeri	Base of os metacarpale II (variance: base of os metacarpale III)		Wrist: flexion and abduction (radial deviation) of hand
③ M. palmaris longus		Aponeurosis palmaris	N. medianus (C7, C8)	Art. cubiti: weak flexion Wrist: flexion tightens aponeurosis palmaris
④ M. flexor carpi ulnaris	Caput humerale: Epicondylus medialis humeri Caput ulnare: olecranon	Os pisiforme; hook of Os hamatum; base of 5th os metacarpale	N. ulnaris (C7–T1)	Wrist: flexion and adduction (ulnar deviation) of hand
Intermediate group				
⑤ M. flexor digitorum superficialis	Caput humerale: Epicondylus medialis humeri Caput ulnare: Processus coronoideus	Sides of phalanges mediales of digitus II to V	N. medianus (C8, T1)	Art. cubiti: weak flexor Wrist, art. metacarpophalangealis, and art. interphalangelais proximalis of digitus II to V: flexion
Deep group				
⑥ M. flexor digitorum profundis	Ulna (two thirds of flexor surface) and membrana interosseous antebrachii	Phalanges distales of digitus II to V (palmar surface)	N. medianus (C8, T1) N. ulnaris (C8, T1)	Wrist, art. metacarpophalangealis, and art. interphalangealis proximalis of digitus II to V: flexion
⑦ M. flexor pollicis longus	Radius (midanterior surface) and adjacent membrana interossea antebrachii	Phalanx distalis pollicis (palmar surface)	N. medianus (C7, C8)	Wrist: flexion and abduction (radial deviation) of hand Art. carpometacarpalis pollicis: flexion Art. metacarpophalangealis pollicis and art. interphalangelis pollicis: flexion
⑧ M. pronator quadratus	Distal quarter of ulna (anterior surface)	Distal quarter of radius (anterior surface)		Hand: pronation Art. radioulnaris distalis: stabilization

DIP = distal interphalangeal; IP = interphalangeal; MCP = metacarpophalangeal; PIP = proximal interphalangeal.

Fig. 20.14 **Superficial and intermediate groups**
Right forearm, anterior view.

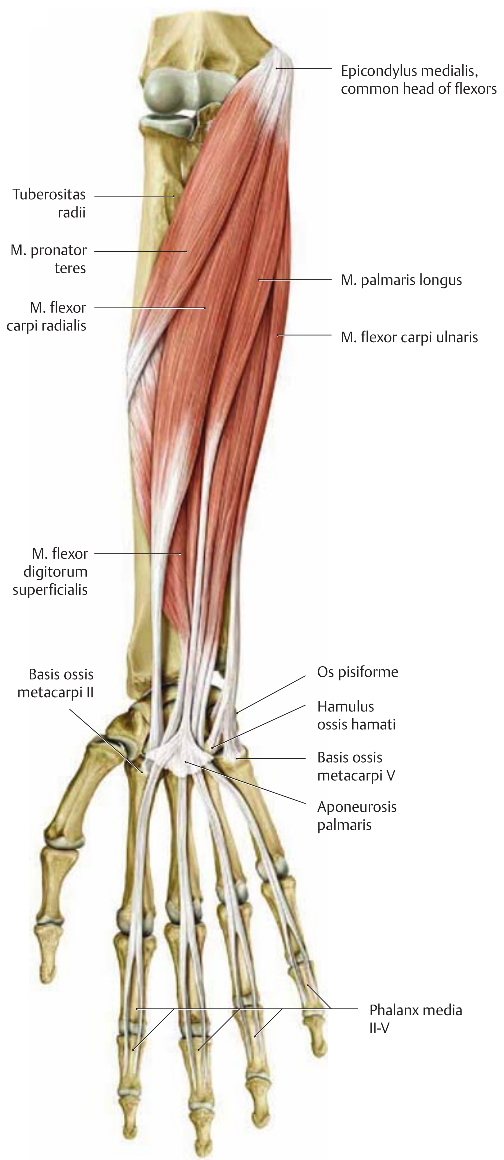
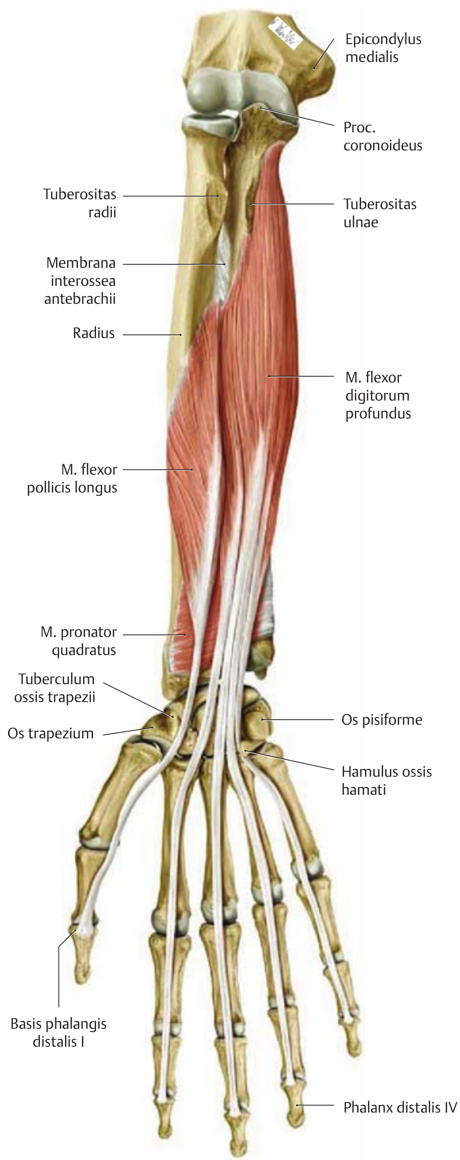


Fig. 20.15 **Deep group**
Right forearm, anterior view.



Muscle Facts (II)

Fig. 20.16 Radialis group
Right forearm, posterior view.

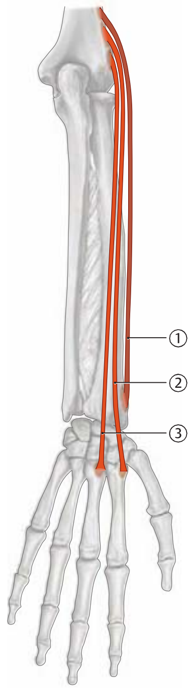
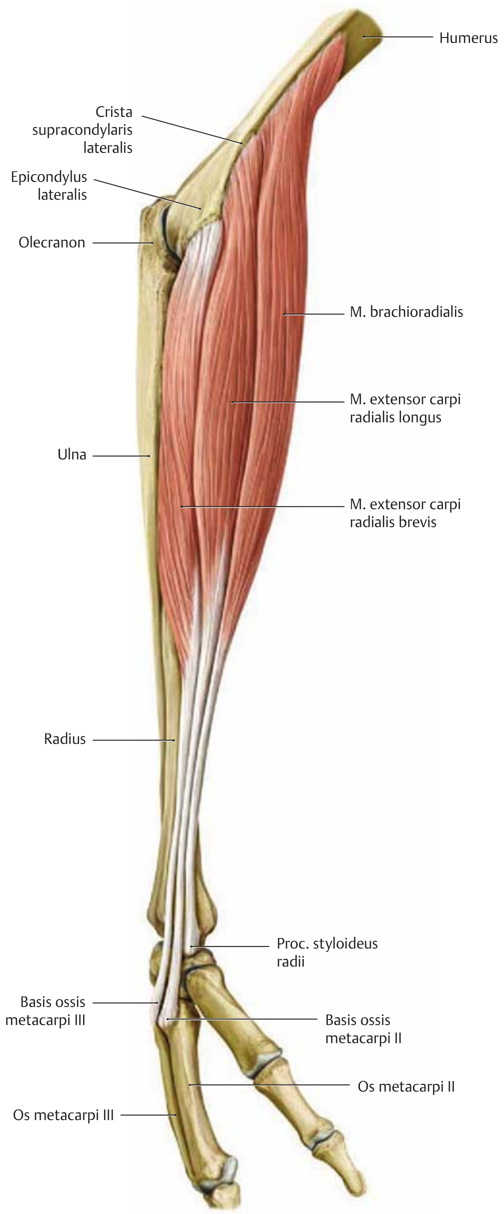


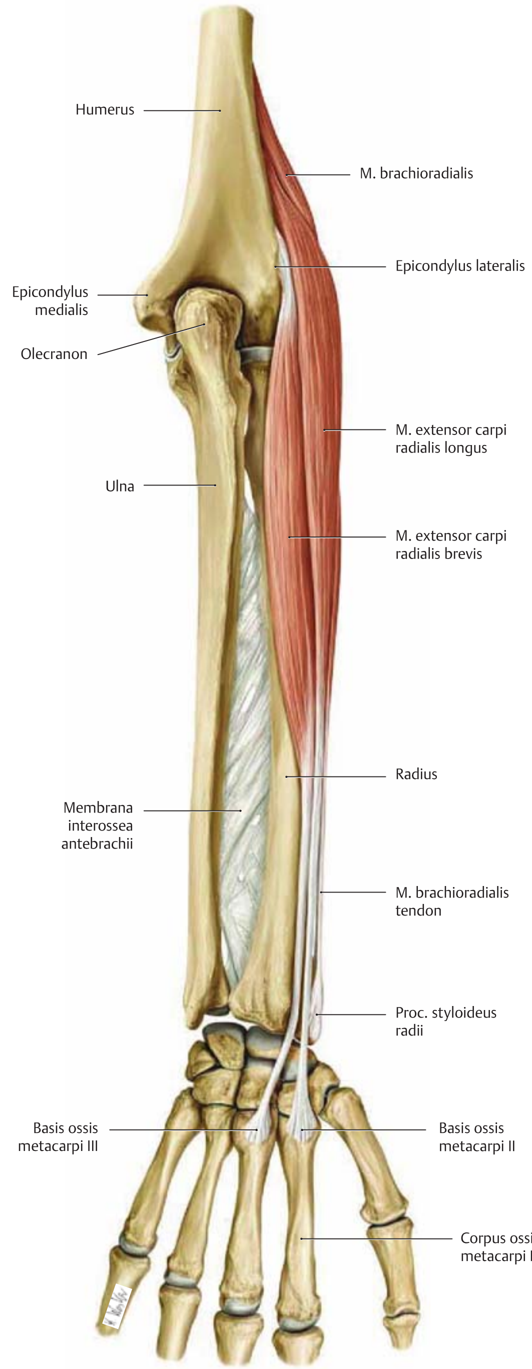
Table 20.3 **Posterior compartment of the forearm: Radialis muscles**

Muscle	Origin	Insertion	Innervation	Action
① M. brachioradialis	Crista supra(epi)condylaris lateralis humeris, septum intermusculare laterale	Proc. styloideus radii	N. radialis (C5, C6)	Art. cubiti: flexion Forearm: semipronation
② M. extensor carpi radialis longus	Crista supra(epi)condylaris lateralis humeris, septum intermusculare laterale	Os metacarpale II	N. radialis (C6, C7)	Art. cubiti: weak flexion Wrist: extension and abduction
③ M. extensor carpi radialis brevis	Epicondylus lateralis humeri	Os metacarpale III	N. radialis (C7, C8)	

Fig. 20.17 **Radialis muscles of the forearm**
Right forearm.



A Lateral (radial) view.



B Posterior view.

Muscle Facts (III)

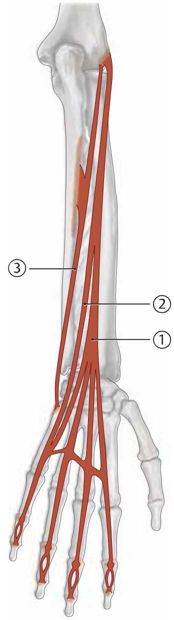


***Fig. 20.18* Superficial group**
Right forearm, posterior view.

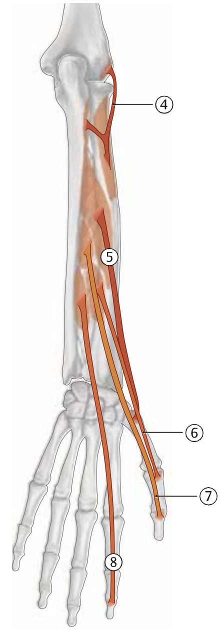


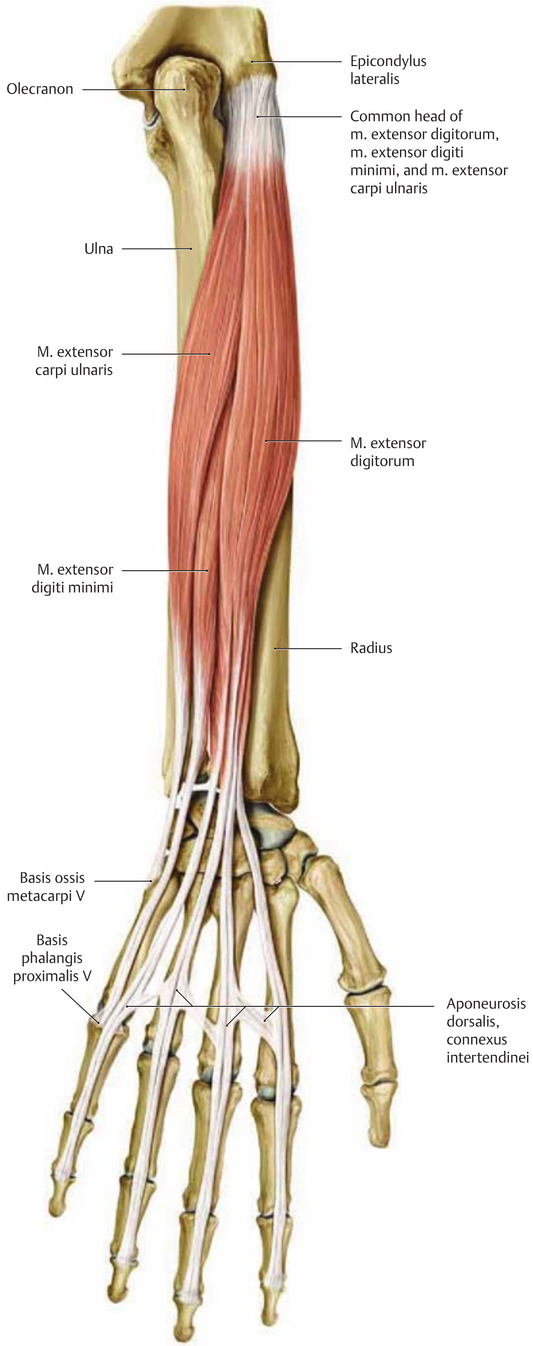
***Fig. 20.19* Deep group**
Right forearm, posterior view.

Table 20.4 **Posterior compartment of the forearm**

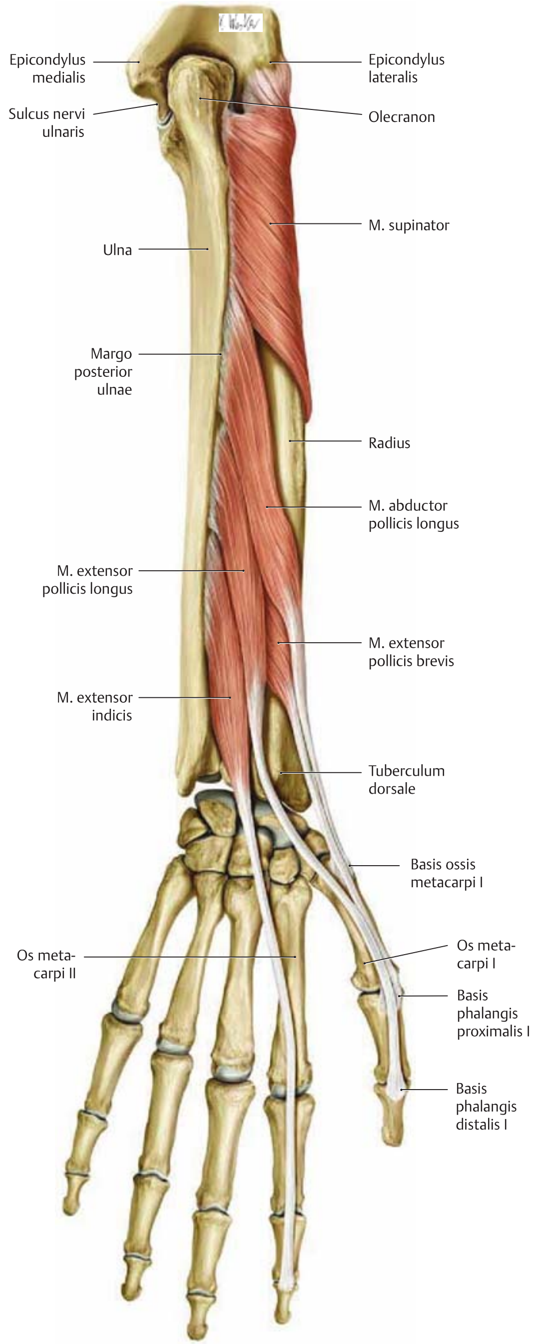
Muscle	Origin	Insertion	Innervation	Action
Superficial group				
① M. extensor digitorum	Epicondylus lateralis humeri	Aponeurosis palmaris digitus II–V	N. radialis (C7, C8)	Wrist: extension MCP, PIP, and DIP of digitus II–V: extension/ abduction of fingers
② M. extensor digiti minimi		Aponeurosis palmaris		Wrist: extension, ulnar abduction of hand MCP, PIP, and DIP of digitus V: extension and abduction of digitus V
③ M. extensor carpi ulnaris	Caput humerale: Epicondylus lat. humeri Caput ulnare: Ulnar	Os metacarpale V		Wrist: extension, adduction (ulnar deviation) of hand
Deep group				
④ M. supinator	Olecranon, Epicondylus lateralis humeri, Lig. collaterale radiale, Lig. anulare radii	Radius (tuberositas radii and insertion of M. pronator teres)	N. radialis (C6, C7)	Articulatio radioulnaris : supination
⑤ M. abductor pollicis longus	Facies dorsalis ulnae et radii, membrana interossea antebrachii	Base of Os metacarpale pollicis	N. radialis (C7, C8)	Articulatio radioulnaris: abduction of the hand Articulatio carpometacarpale pollicis: abduction
⑥ M. extensor pollicis brevis	Facies dorsalis radii and membrana interossea antebrachii	Base of Phalanx proximalis pollicis		Articulatio radiocarpale: abduction (radial deviation) of hand Art. carpometacarpale and art. metacarpophangealis pollicis : extension
⑦ M. extensor pollicis longus	Facies dorsalis ulnae and membrana interossea antebrachii	Base of Phalanx proximalis pollicis		Wrist: extension and abduction (radial deviation) of hand Art. carpometacarpale pollicis : adduction MCP and IP of thumb: extension
⑧ M. extensor indicis	Facies dorsalis ulnae, Membrana interossea antebrachii	Posterior digital extension of digitus II		Wrist: extension MCP, PIP, and DIP of digitus II: extension

DIP = distal interphalangeal; IP = interphalangeal; MCP = metacarpophalangeal; PIP = proximal interphalangeal.

Fig. 20.20 **Muscles of the posterior forearm**
Right forearm, posterior view.



A Superficial extensors.



B Deep extensors with m. supinator.

Bones of the Wrist & Hand

Table 21.1	Bones of the wrist and hand	
Ossa digitorum manus	Phalanges proximales I–V	
	Phalanges mediales II–V*	
	Phalanges distales I–V	
Ossa metacarpi	Ossa metacarpalia I–V	
Ossa carpi	Os trapezium	Os scaphoi-deum
	Os trapezoi-deum	Os lunatum
	Os capitatum	Os triquetrum
	Os hamatum	

*There are only four middle phalanges (the thumb has only a proximal and a distal phalanx).

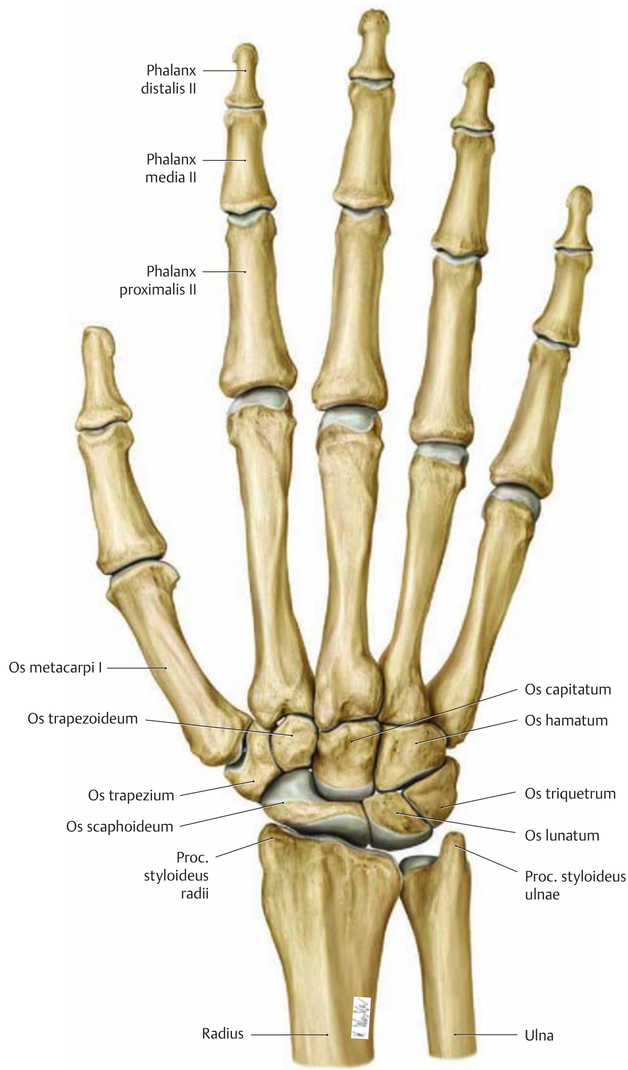


Fig. 21.1 **Dorsal view**
Right hand.

Fig. 21.2 **Palmar view**
Right hand.

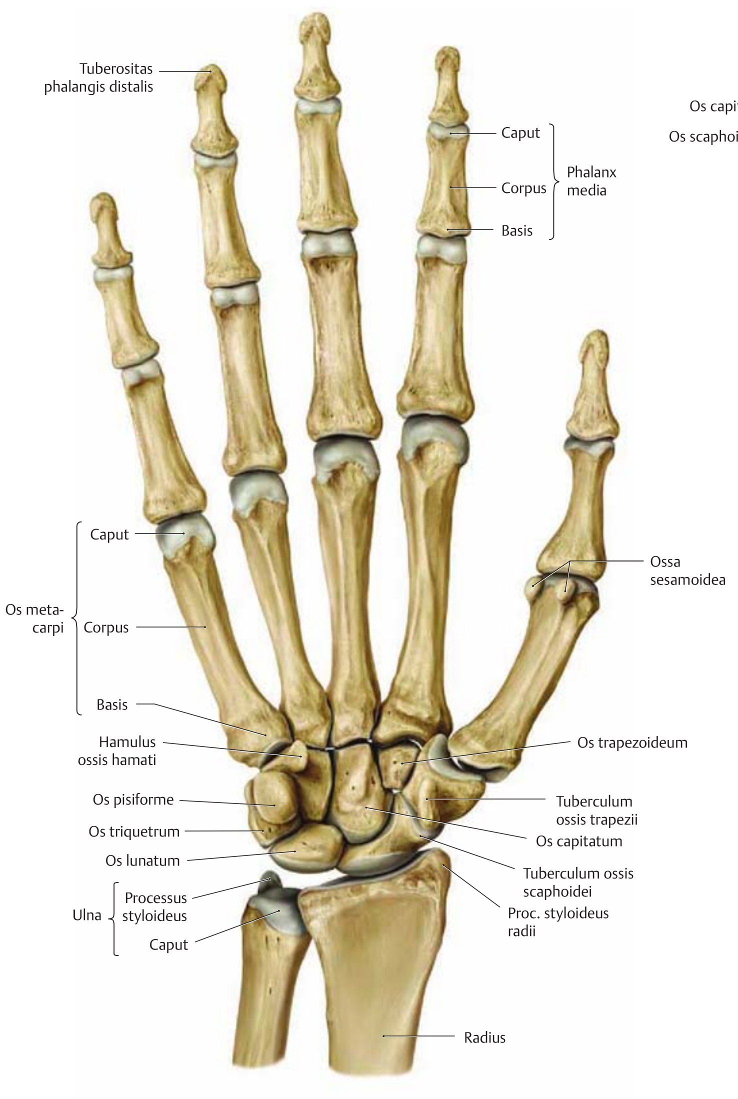
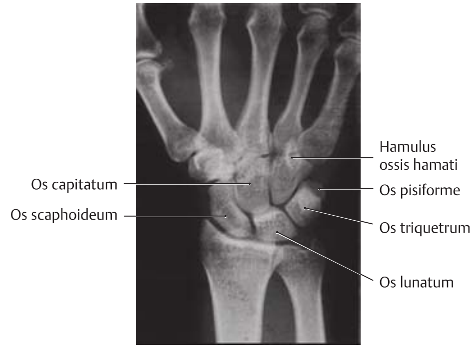


Fig. 21.3 **Radiograph of the wrist**
Anteroposterior view of left limb.



Clinical

Fractures of os scaphoideum
Fractures of os scaphoideum are the most common carpal bone fractures, generally occurring at the narrowed waist between the proximal and distal poles (**A**, right scaphoid). Because blood supply to os scaphoideum is transmitted via the distal segment, fractures at the waist can compromise the supply to the proximal segment, often resulting in nonunion and avascular necrosis.

A

B

Joints of the Wrist & Hand

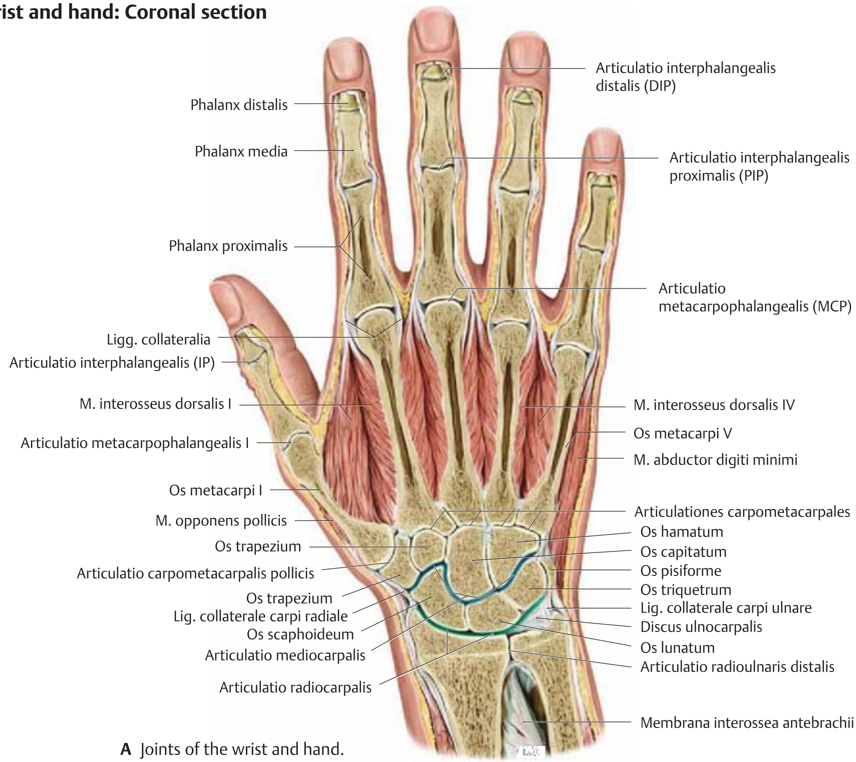
***Fig. 21.4* Joints of the wrist and hand**

A Joints of the wrist and hand. Right hand, posterior (dorsal) view.

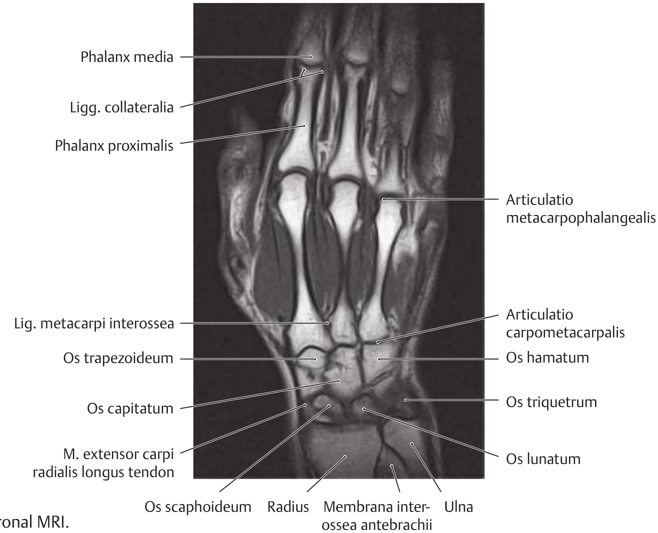
B Articulatio carpometacarpalis pollicis. Radial view. The os metacarpi I has been moved slightly distally to expose the articular surface of os trapezium. Two cardinal axes of motion are shown here: (**a**) flexion/extension and (**b**) abduction/adduction.

C Radiograph of wrist. Radial view.

Fig. 21.5 Wrist and hand: Coronal section
Right hand.



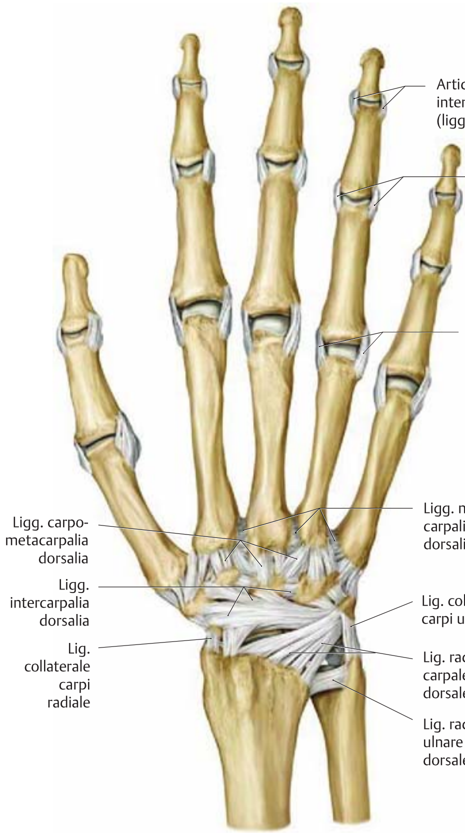
A Joints of the wrist and hand.



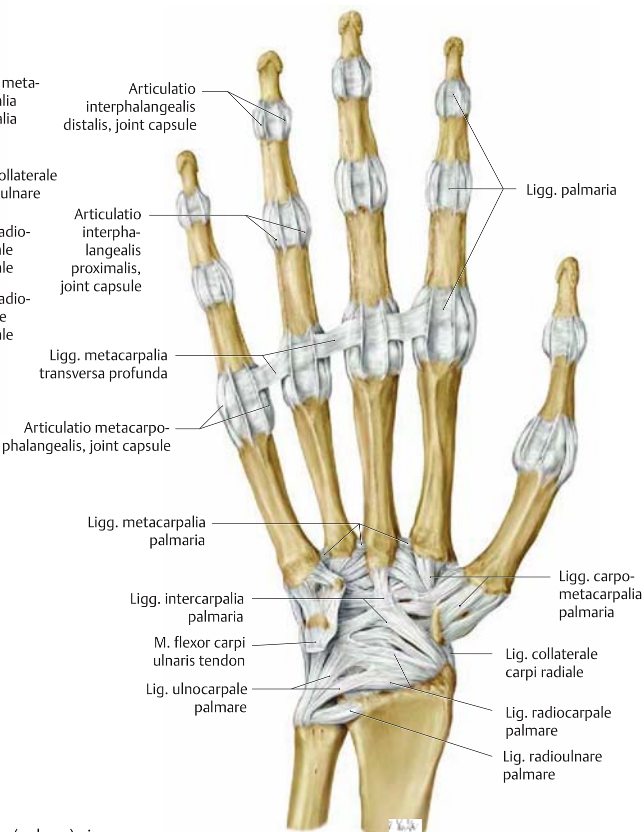
B Coronal MRI.

Ligaments of the Wrist & Hand

***Fig. 21.6* Ligaments of the hand**
Right hand.



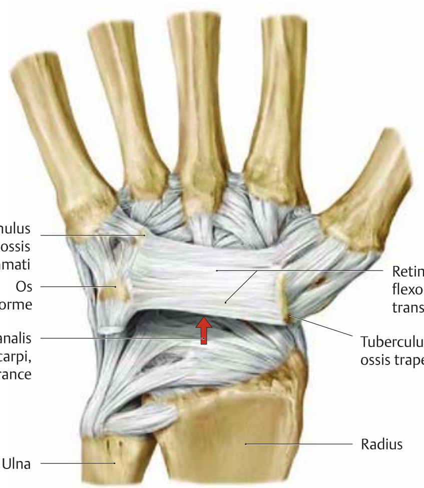
A Posterior (dorsal) view.



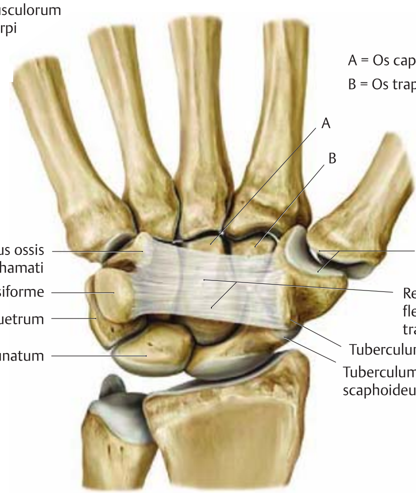
B Anterior (palmar) view.

Fig. 21.7 Ligaments of canalis carpi

Right hand, anterior view.



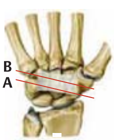
A Canalis carpi and retinaculum musculorum flexorum.

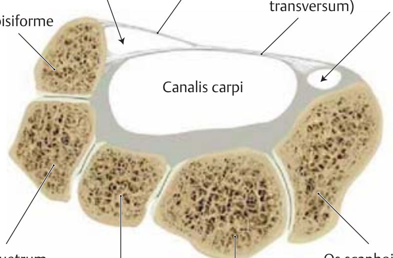


B Bony boundaries of canalis carpi.

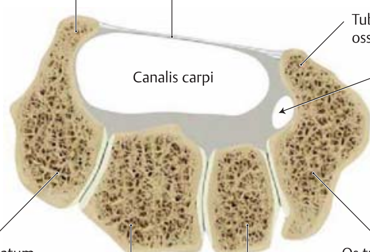
Fig. 21.8 Canalis carpi

Transverse section. The contents of canalis carpi are discussed on p. 342. See p. 343 for canalis ulnaris and lig. carpi palmare.





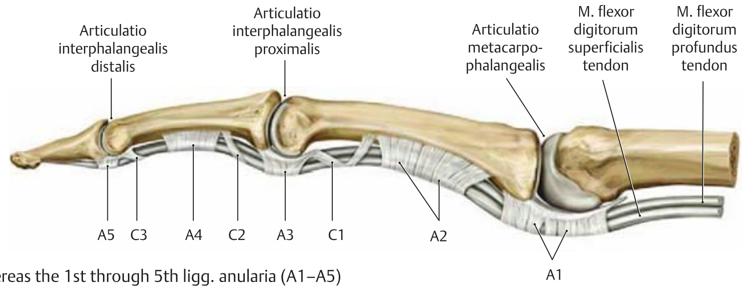
A Proximal part of canalis carpi.



B Distal part of canalis carpi.

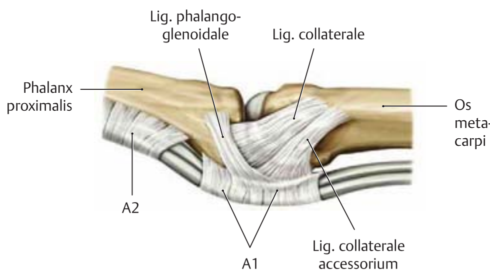
Ligaments of the Fingers

Fig. 21.9 **Ligaments of the fingers: Lateral view**
Right middle finger. The outer fibrous layer of the tendon sheaths (stratum fibrosum) is strengthened by ligg. anularia and ligg. obliqua, which also bind the sheaths to the palmar surface of the phalanx and prevent palmar deviation of the sheaths during flexion.



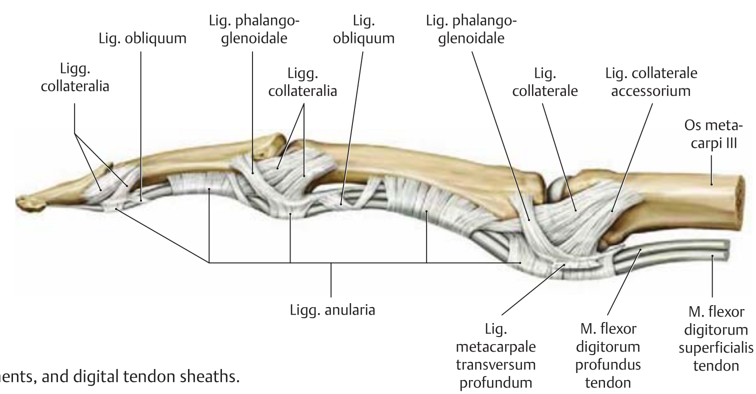
A Extension. *Note:* Whereas the 1st through 5th ligg. anularia (A1–A5) have fixed positions, the ligg. obliqua (C1–C3) are highly variable in their course.

B Flexion.



C Extension of articulatio metacarpophalangea. *Note:* The collateral ligament is lax.

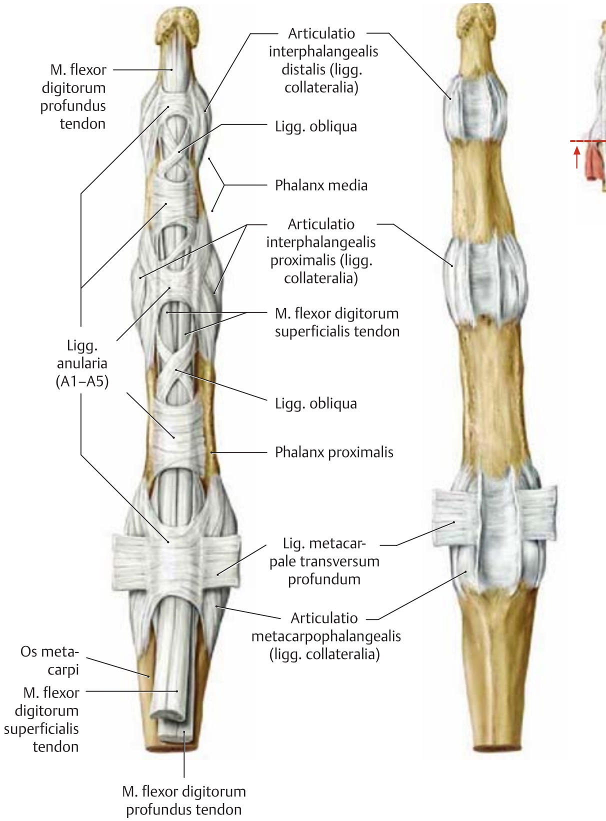
D Flexion of articulatio metacarpophalangea. *Note:* The collateral ligament is taut.



E Joint capsules, ligaments, and digital tendon sheaths.

Fig. 21.10 **Anterior view**
Right middle finger, palmar view.

Fig. 21.11 **Os metacarpi III: Transverse section**
Proximal view.



A Superficial ligaments.

B Deep ligaments with digital tendon sheath removed.

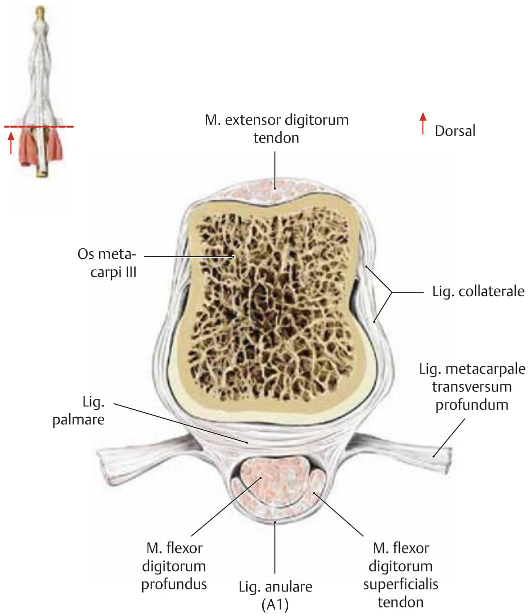
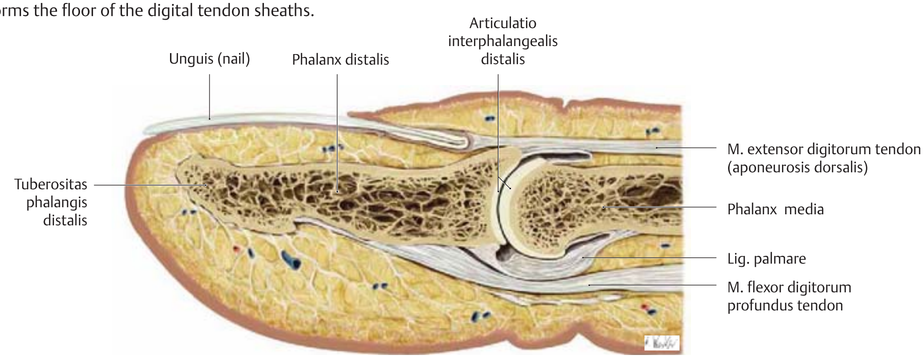
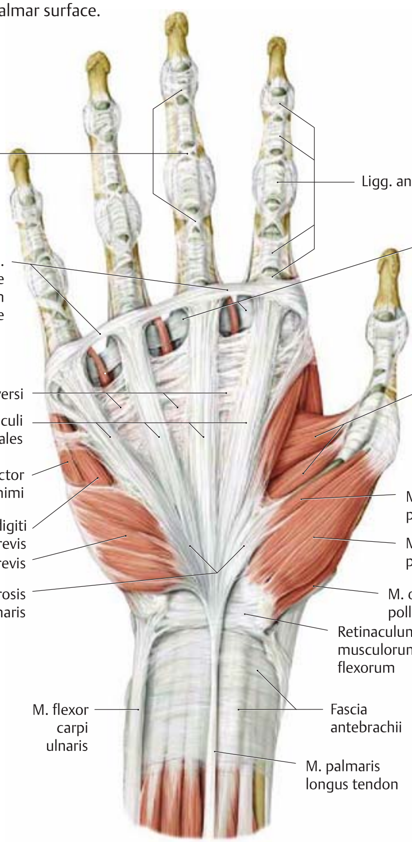


Fig. 21.12 **Fingertip: Longitudinal section**
The palmar articular surfaces of the phalanges are enlarged proximally at the joints by the lig. palmare. This fibrocartilaginous plate, also known as the volar plate, forms the floor of the digital tendon sheaths.



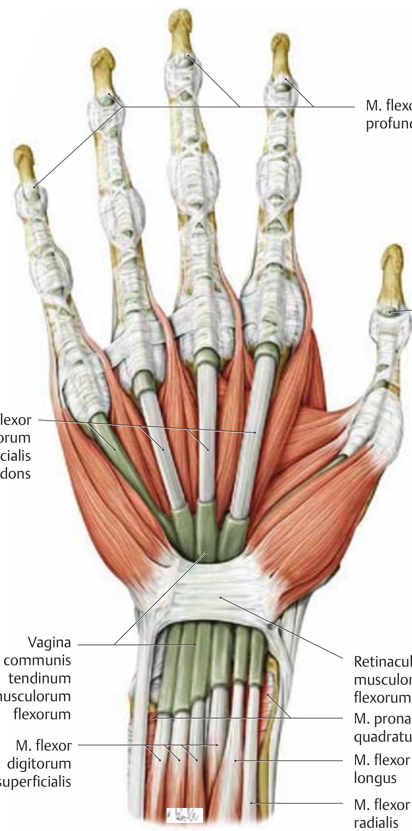
Muscles of the Hand: Superficial & Middle Layers

Fig. 21.13 Intrinsic muscles of the hand: Superficial and middle layers
Right hand, palmar surface.



A Aponeuros palmaris.

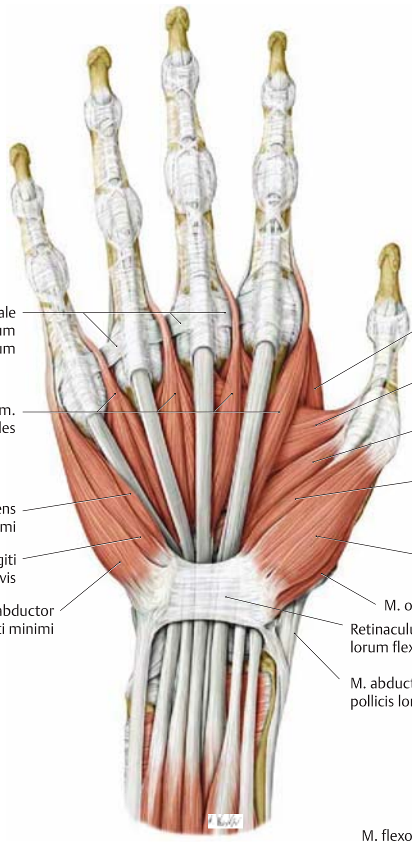
*Also known as lig. carpi transversum.



B Carpal and digital tendon sheaths. *Removed:* Aponeurosis palmaris, m. palmaris longus, fascia antebrachii, and m. palmaris brevis.

Clinical

Dupuytren's contracture
Gradual atrophy of aponeurosis palmaris leads to progressive shortening of the palmar fascia, chiefly affecting the 4th and 5th digits. Over a period of years, the contracture may become so severe that the fingers assume a flexed position (with fingertips touching the palms), severely compromising the grasping ability of the hand. The causes of Dupuytren's contracture are poorly understood, but it is a relatively common condition, most prevalent in men over 40 and associated with chronic liver disease (i.e., cirrhosis). Treatment generally consists of complete surgical removal of the palmar aponeurosis.

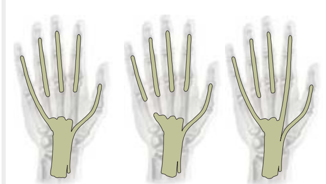


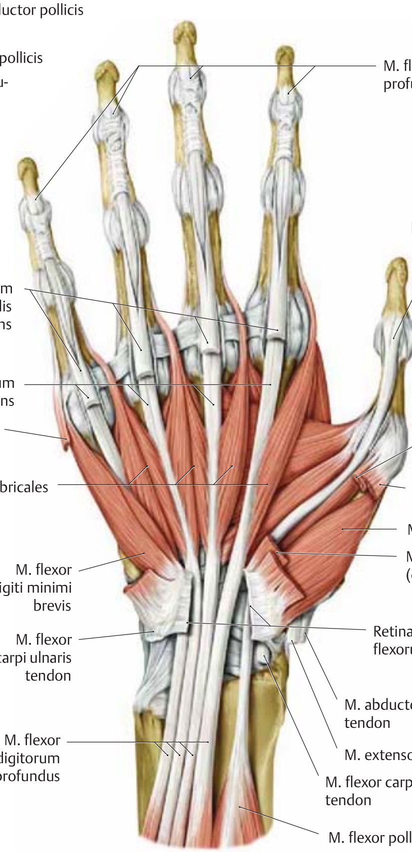
C Superficial muscles of the hand. *Removed:* Tendon sheaths.

Clinical

Tendon sheath communication

The digital tendon sheath of the thumb is continuous with the carpal tendon sheath of the pollicis longus. The remaining fingers show variable communication with the carpal tendon sheaths (**A** is the most common variation). Infections within the tendon sheaths from puncture wounds of the fingers can track proximally to communicating spaces of the hand.

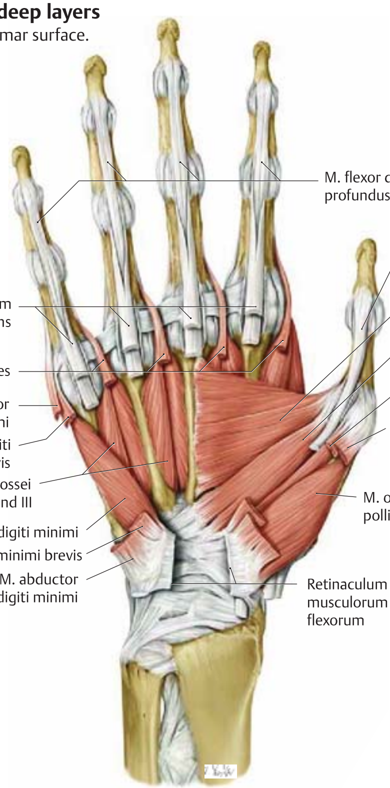




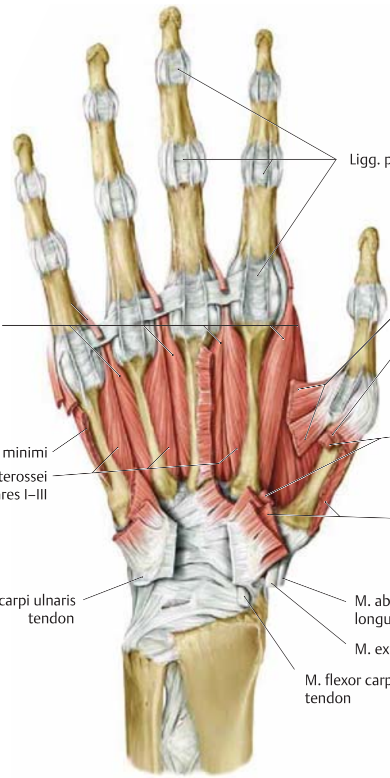
D Middle layer of muscles. *Removed:* M. flexor digitorum superficialis, mm. flexor carpi radialis and ulnaris, and m. pronator quadratus.

Muscles of the Hand: Middle & Deep Layers

Fig. 21.14 **Intrinsic muscles: Middle and deep layers**
Right hand, palmar surface.

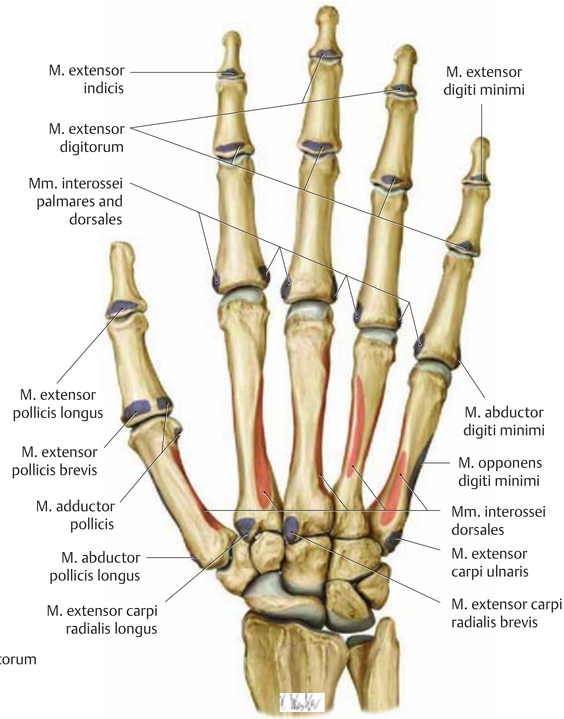


A Middle layer of muscles of the hand. *Cut:* M. flexor digitorum profundus, mm. lumbricales, m. flexor pollicis longus, and m. flexor digiti minimi.

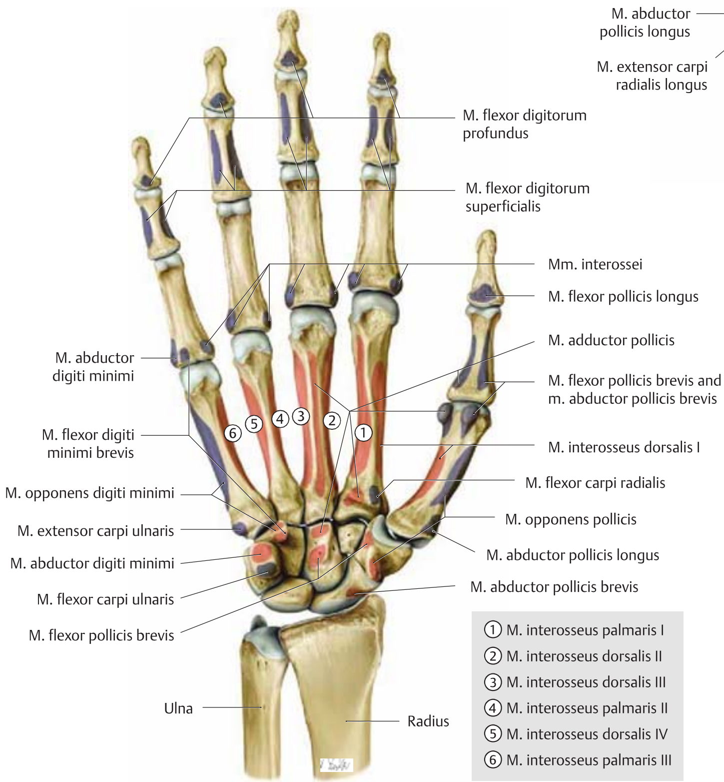


B Deep muscles of the hand. *Cut:* M. opponens digiti minimi, m. opponens pollicis, m. flexor pollicis brevis, and m. adductor pollicis (caput transversum and caput obliquum).

Fig. 21.15 **Origins and insertions**
Right hand. Muscle origins shown in red, insertions in blue.



A Dorsal (posterior) view.



B Palmar (anterior) view.

Dorsum of the Hand

Fig. 21.16 **Retinaculum musculorum extensorum and dorsal carpal tendon sheaths**
Right hand, posterior (dorsal) view.

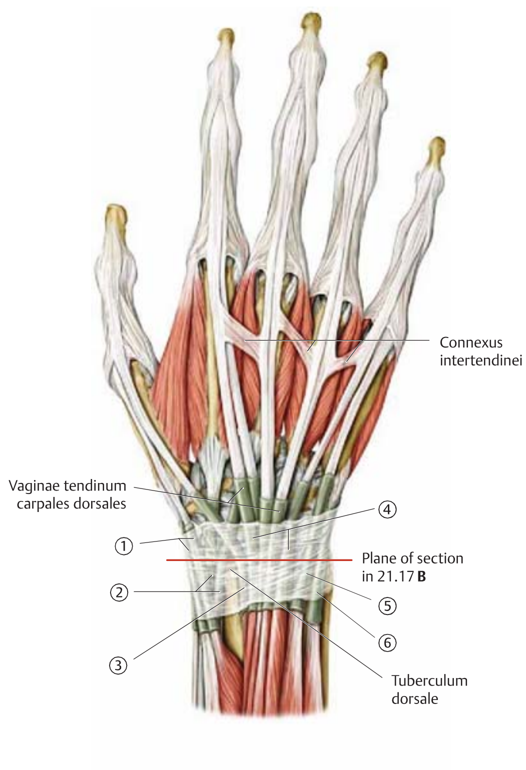
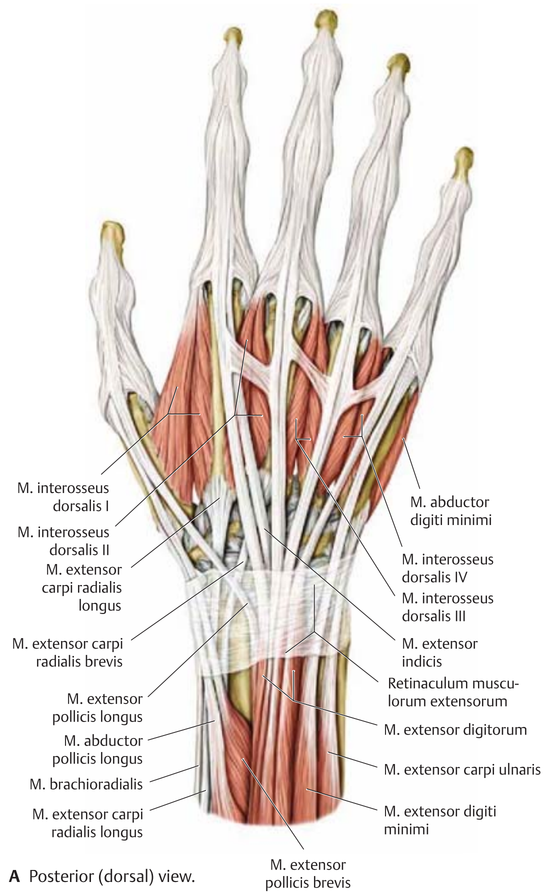
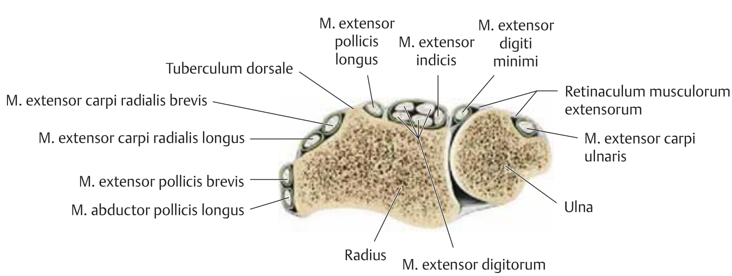


Fig. 21.17 **Muscles and tendons of the dorsum**
Right hand.



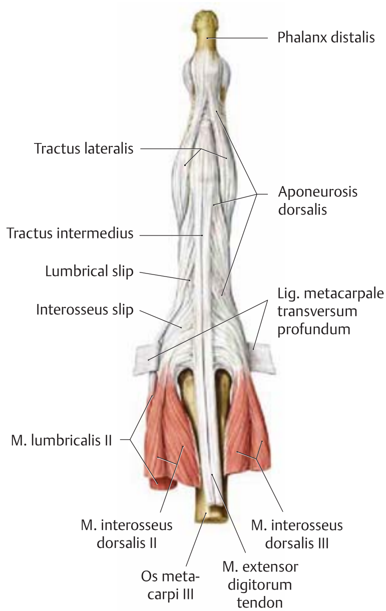
A Posterior (dorsal) view.

Table 21.2	**Dorsal compartments for extensor tendons**
①	M. abductor pollicis longus
	M. extensor pollicis brevis
②	M. extensor carpi radialis longus
	M. extensor carpi radialis brevis
③	M. extensor pollicis longus
④	M. extensor digitorum
	M. extensor indicis
⑤	M. extensor digiti minimi
⑥	M. extensor carpi ulnaris

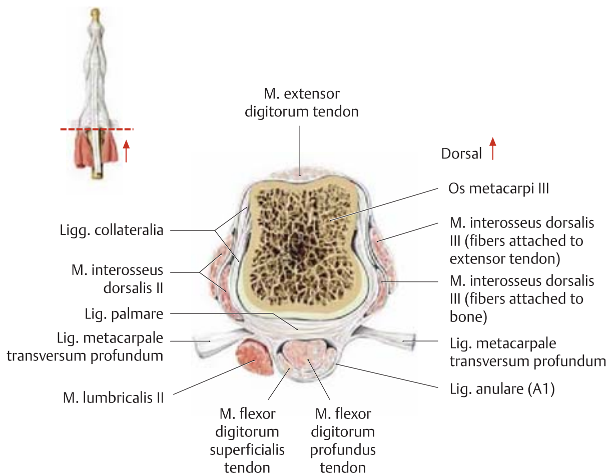


B Dorsal compartments, proximal view of section in Fig. 21.16.

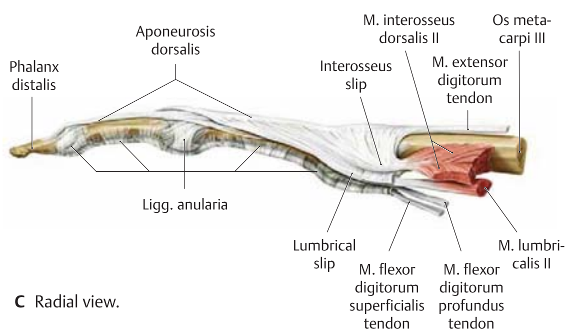
Fig. 21.18 **Aponeurosis dorsalis**
Right hand, middle finger. The aponeuroses dorsales permits the long digital flexors and the short muscles of the hand to act on all three finger joints.



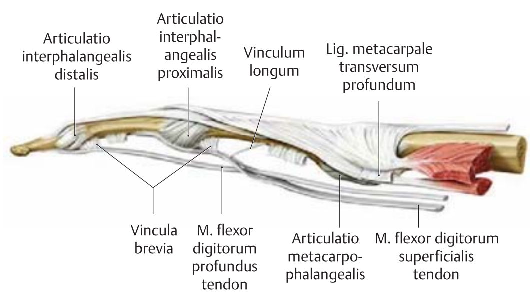
A Posterior view.



B Cross section through caput os metacarpi III, proximal view.



C Radial view.



D Radial view with common tendon sheath of mm. flexor digitorum superficialis and profundus opened.

Muscle Facts (I)

The intrinsic muscles of the hand are divided into three groups: the thenar, hypothenar, and metacarpal muscles (see p. 314). The thenar muscles are responsible for movement of the thumb, while the hypothenar muscles move the 5th digit.

Table 21.3 Mm. thenares

Muscle	Origin	Insertion		Innervation		Action
① M. adductor pollicis	Caput transversum: Os metacarpale III (facies palmaris)	Thumb (base of phalanx proximalis)	Via os sesamoideum ulnaris	N. ulnaris	C8, T1	Art. carpometacarpalis pollicis: adduction Art. metacarpophangealis pollicis : flexion
	Caput obliquum: Os capitatum, os metacarpale II and III					
② M. abductor pollicis brevis	Os scaphoideum and os trapezium, retinaculum flexorum		Via os sesamoideus m. radialis	N. medianus		Art. carpometacarpalis pollicis: abduction
③ M. flexor pollicis brevis	Caput superficiale: Retinaculum flexorum			Caput superficiale: N. medianus		Art. carpometacarpalis pollicis: flexion
	Caput profundum: Os capitatum, Os trapezium			Caput profundum: N. ulnaris		
④ M. opponens pollicis	Os trapezium	Os metacarpale I (Facies radialis)		N. medianus		Art. carpometacarpalis pollicis: opposition

CMC = carpometacarpal; MCP = metacarpophalangeal.

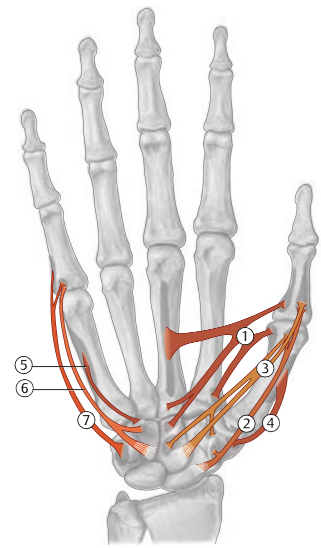


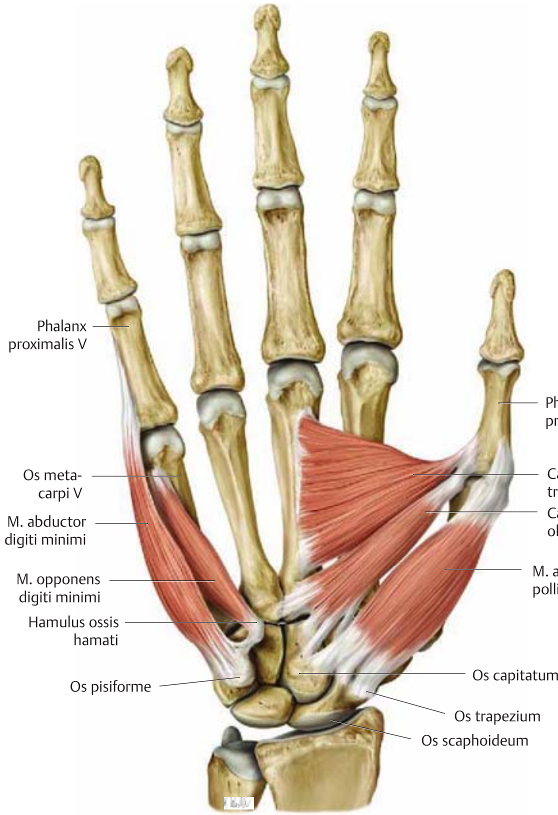
Fig. 21.19 **Thenar and hypothenar muscles**
Right hand, palmar (anterior) view.

Table 21.4 Mm. hypothenares

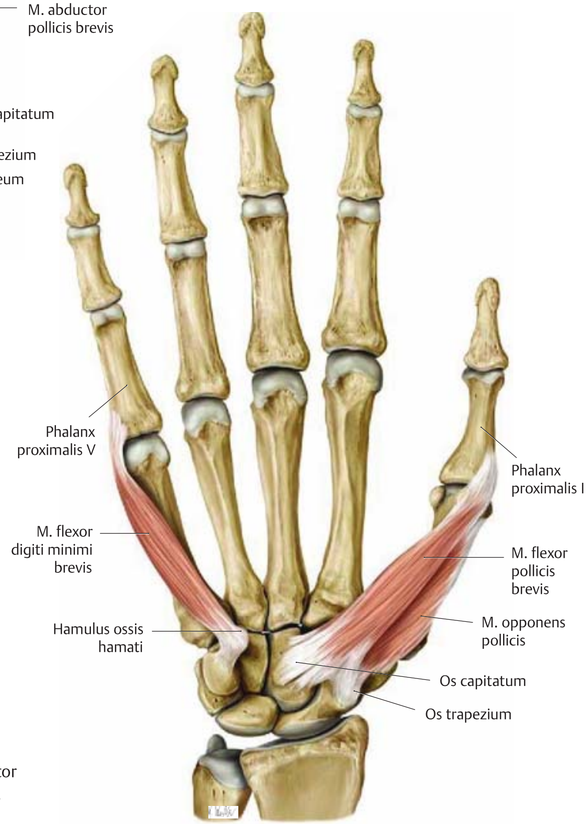
Muscle	Origin	Insertion	Innervation	Action
⑤ M. opponens digiti minimi	Hook of os hamatum, retinaculum flexorum	Os metacarpale V (facies ulnaris)	N. ulnaris (C8, T1)	Draws metacarpal in palmar direction (opposition)
⑥ M. flexor digiti minimi		Phalanx proximalis V (base)		Art. metcarpophalangealis digitus minimus: flexion
⑦ M. abductor digiti minimi	Os pisiforme	Phalanx proximalis (ulnar base) and dorsal digital expansion of digitus V		C digitus minimus: flexion and abduction of little finger Art. interphalangealis proximalis (PIP) and art. interphalangealis distalis (DIP) of digitus minimus: extension
M. palmaris brevis	Aponeurosis palmaris (facies ulnaris)	Aponeurosis palmaris		Tightens the aponeurosis palmaris (protective function)

DIP = distal interphalangeal; MCP = metacarpophalangeal; PIP = proximal interphalangeal.

Fig. 21.20 **Thenar and hypothenar muscles**
Right hand, palmar (anterior) view.



A *Removed:* M. flexor pollicis brevis, m. opponens pollicis, and m. flexor digiti minimi.



B *Removed:* M. adductor pollicis, m. abductor pollicis brevis, m. abductor digiti minimi, and m. opponens digiti minimi.

Muscle Facts (II)

The metacarpal muscles of the hand consist of mm. lumbricales and interossei. They are responsible for the movement of the digits (with the hypothenars, which act on the 5th digit).

Fig. 21.21 **Mm. lumbricales**
Right hand, palmar view.

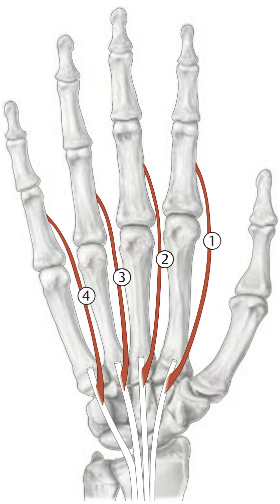


Fig. 21.22 **Mm. interossei dorsales**
Right hand, palmar view.

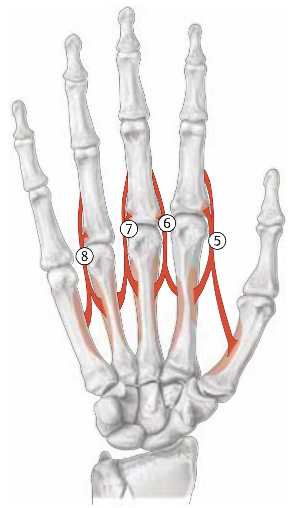


Fig. 21.23 **Mm. interossei palmares**
Right hand, palmar view.

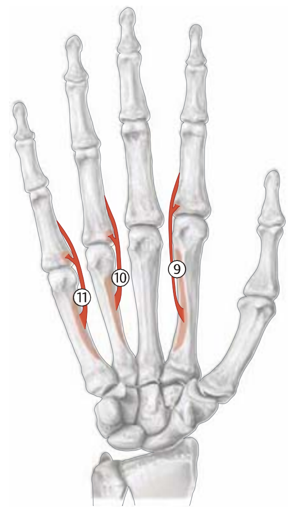
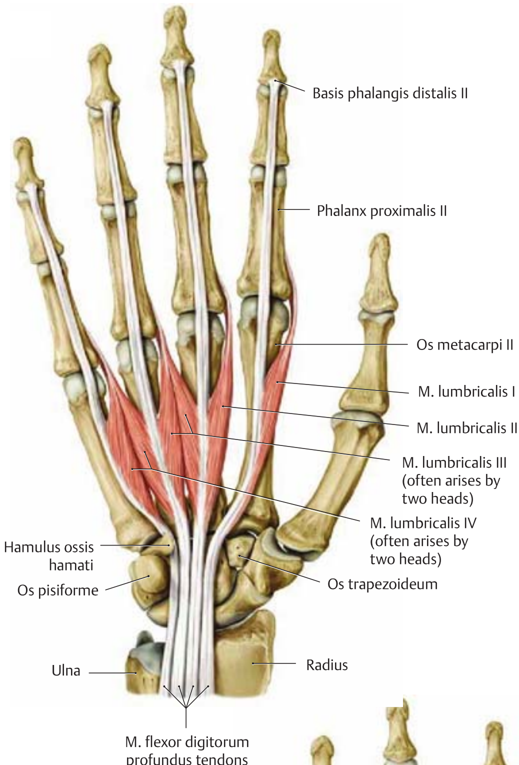


Table 21.5 **Mm. metacarpales**

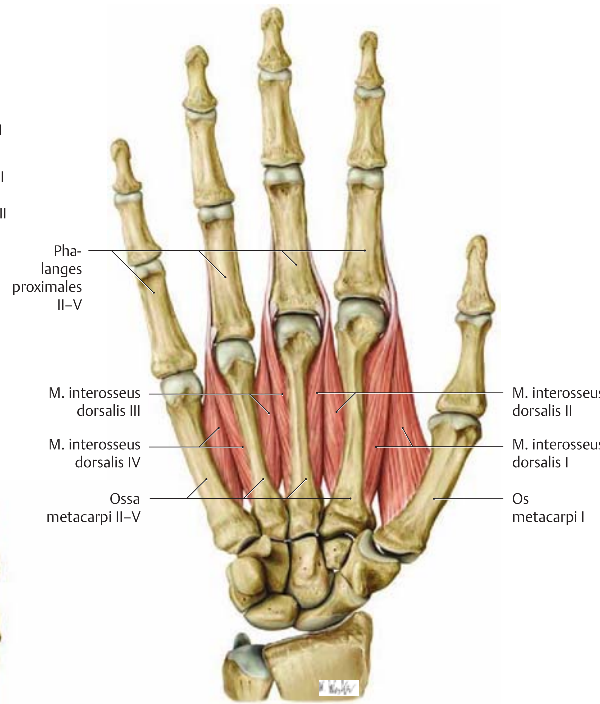
Muscle group	Muscle	Origin	Insertion	Innervation	Action
Mm. lumbricales	① 1st	Tendo m. flexor digitorum profundus (radial sides)	Aponeurosis dorsalis digitus II	N. medianus (C8, T1)	Digitus II–V: • Art. metcarpophalangealis: flexion • Articulationes interphalangeles proximalis et distales: extension
	② 2nd		Aponeurosis dorsalis digitus III		
	③ 3rd	Tendo m. flexor digitorum profundus (bipennate from medial and lateral sides)	Aponeurosis dorsalis digitus IV	N. ulnaris (C8, T1)	
	④ 4th		Aponeurosis dorsalis digitus V		
Mm. interossei dorsales	⑤ 1st	Ossa metacarpales I and II (adjacent sides, two heads)	Aponeurosis dorsalis digitus II, phalanx proximalis II (facies radialis)		Digitus II–IV: • Art. metcarpophalangealis: flexion • Articulationes interphalangeles proximalis et distales: extension and abduction from digitus III
	⑥ 2nd	Os metacarpales II and III (adjacent sides, two heads)	Aponeurosis dorsalis digitus III, phalanx proximalis III (facies radialis)		
	⑦ 3rd	Os metacarpales III and IV (adjacent sides, two heads)	Aponeurosis dorsalis digitus III, phalanx proximalis III (facies ulnaris)		
	⑧ 4th	Os metacarpales IV and V (adjacent sides, two heads)	Aponeurosis dorsalis digitus IV, phalanx proximalis IV (facies ulnaris)		
Mm. interossei palmares	⑨ 1st	Os metacarpale II (facies ulnaris)	Aponeurosis dorsalis digitus II, phalanx proximalis II (base)		Digitus II, IV and V : • Art. metcarpophalangealis: flexion • Articulationes interphalangeles proximalis et distales: extension and adduction toward digitus III
	⑩ 2nd	Os metacarpale IV (facies radialis)	Aponeurosis dorsalis digitus IV, phalanx proximalis IV (base)		
	⑪ 3rd	Os metacarpale V (facies radialis	Aponeurosis dorsalis digitus V phalanx proximalis V (base)		

dde = dorsal digital expansion; IP = interphalangeal; MCP = metacarpophalangeal.

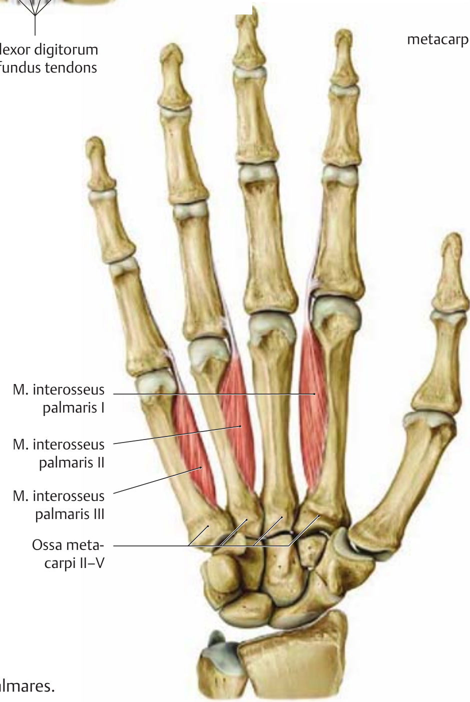
Fig. 21.24 **Metacarpal muscles**
Right hand, palmar (anterior) view.



A Mm. lumbricales.



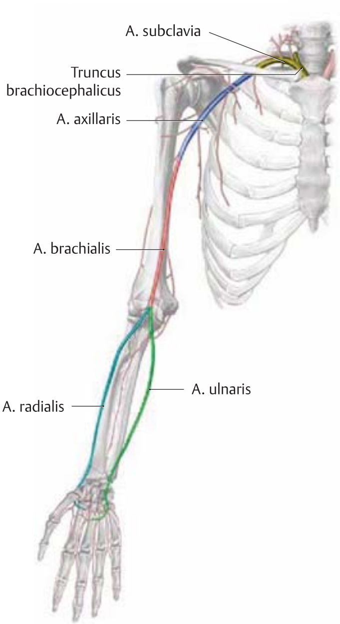
B Mm. interossei dorsales.



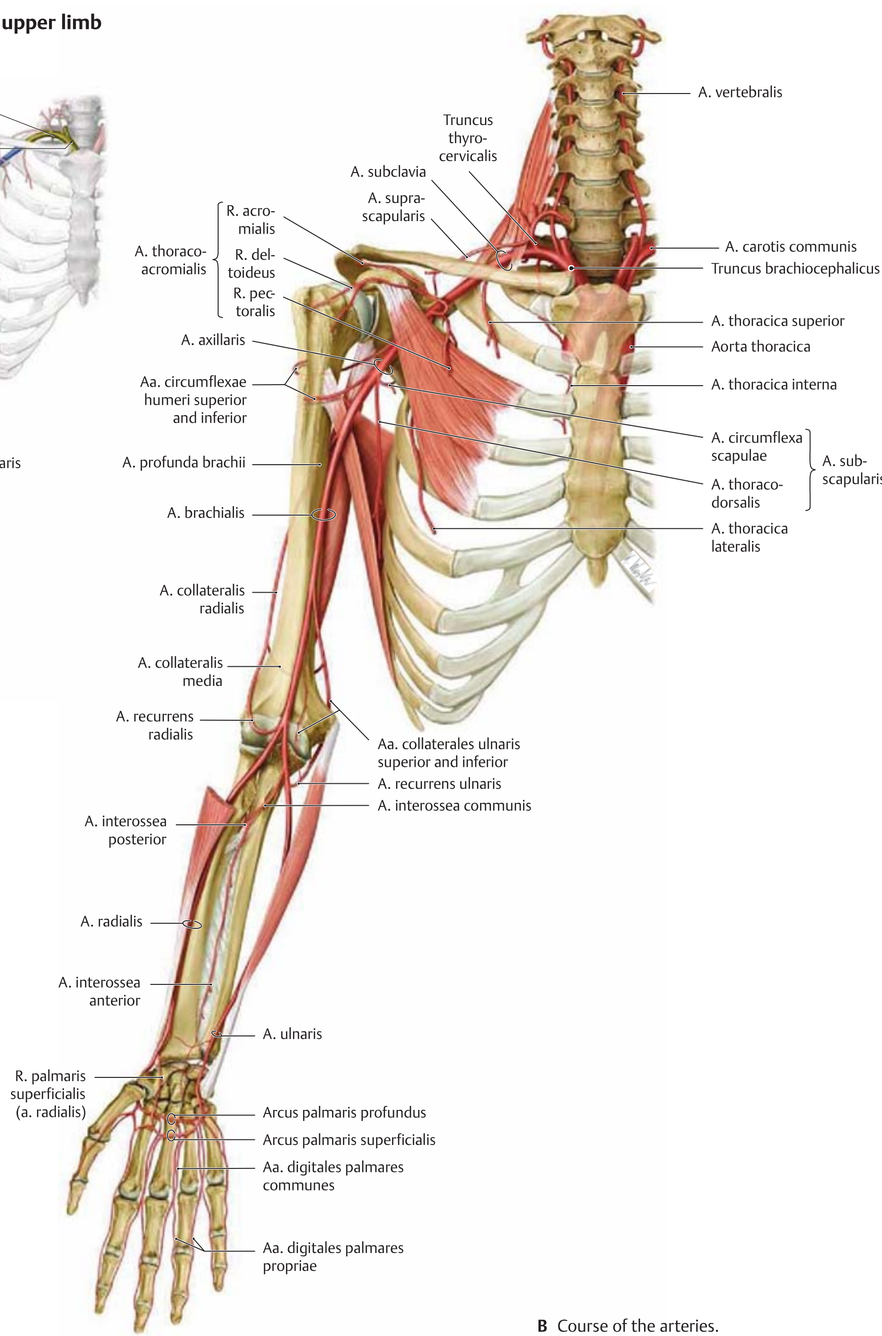
C Mm. interossei palmares.

Arteries of the Upper Limb

Fig. 22.1 **Arteries of the upper limb**
Right limb, anterior view.



A Main arterial segments.



B Course of the arteries.

Fig. 22.2 **Branches of a. subclavia**
Right side, anterior view.

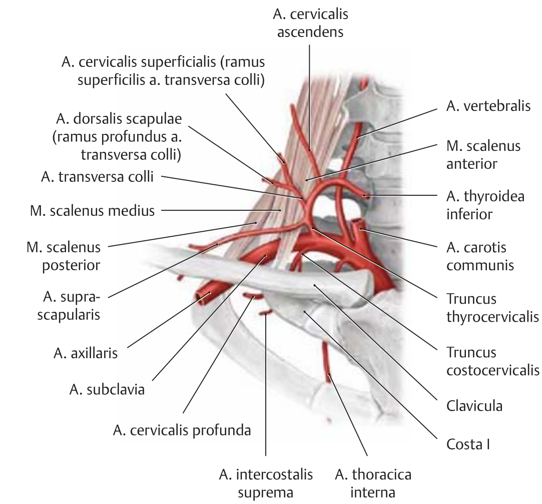


Fig. 22.3 **Scapular arcade**
Right side, posterior view.

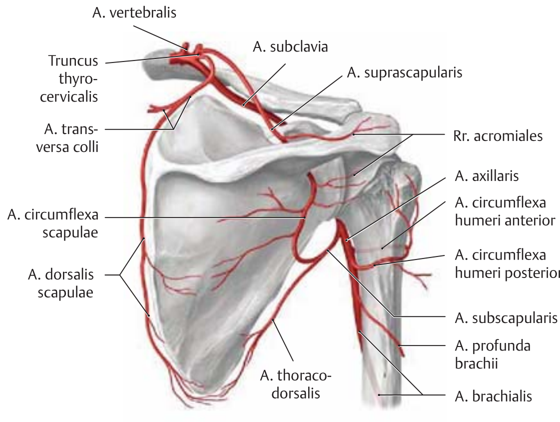
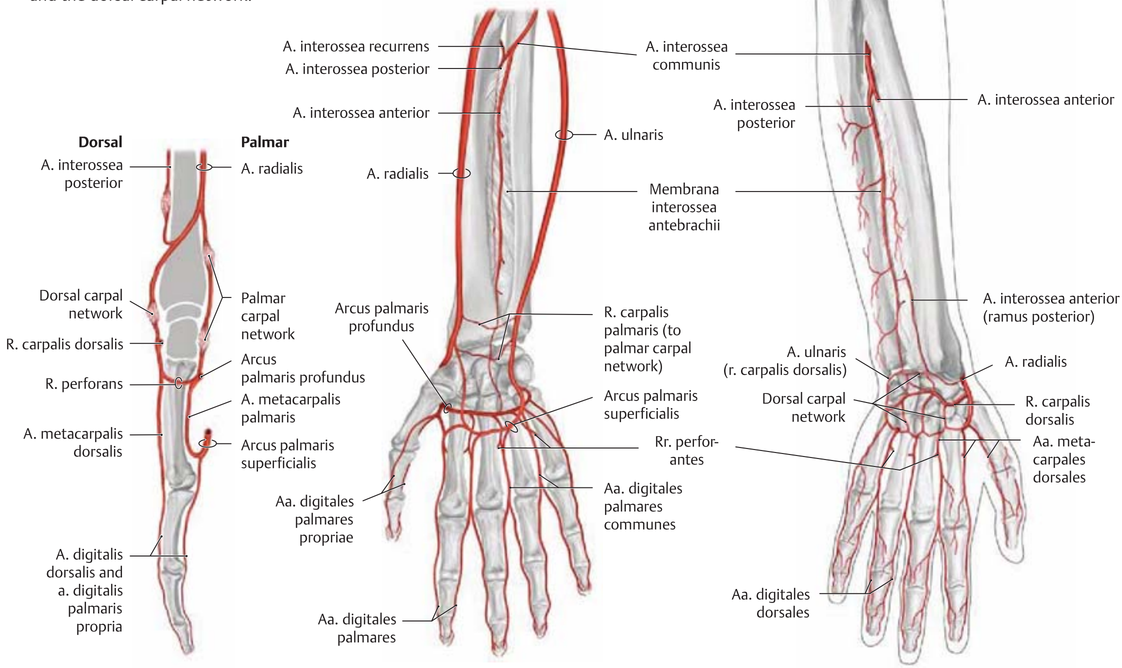


Fig. 22.4 **Arteries of the forearm and hand**
Right limb. A. ulnaris and a. radialis are interconnected by the arcus palmaris superficialis and arcus palmaris profundus, the rr. perforantes, and the dorsal carpal network.



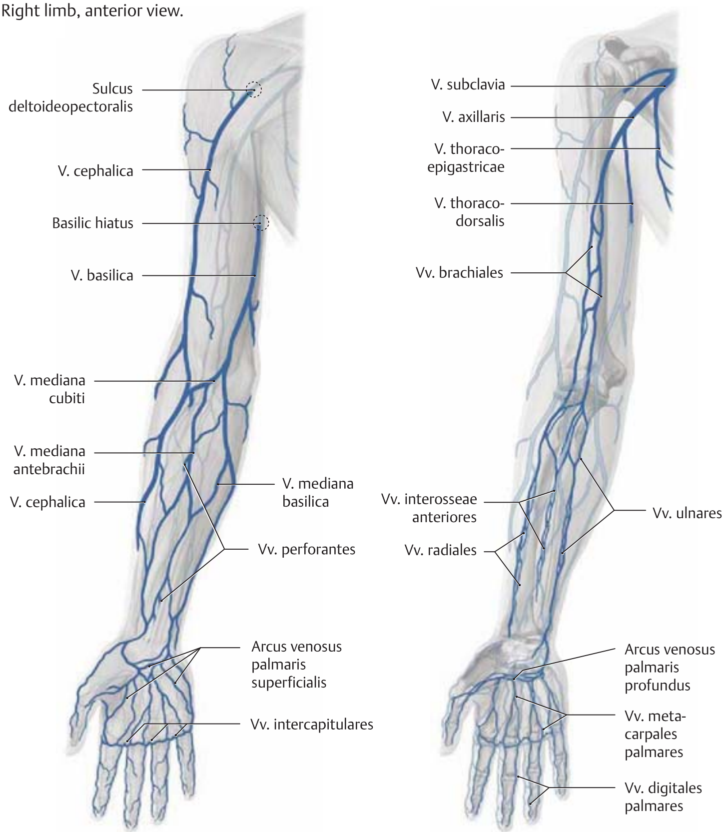
A Right middle finger, lateral view.

B Anterior (palmar) view.

C Posterior (dorsal) view.

Veins & Lymphatics of the Upper Limb

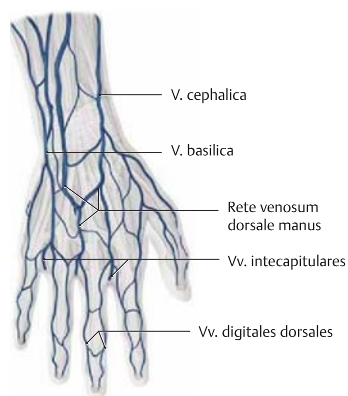
Fig. 22.5 **Veins of the upper limb**
Right limb, anterior view.



A Superficial veins.

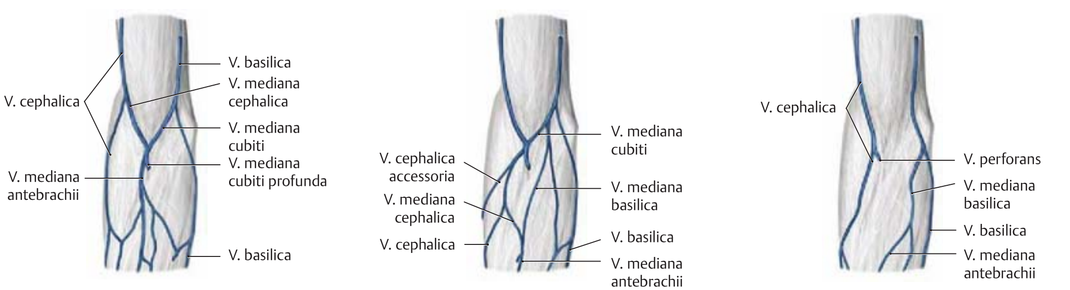
B Deep veins.

Fig. 22.6 **Veins of the dorsum**
Right hand, posterior view.



> ***Clinical***
>
> **Venipuncture**
> The veins of fossa cubitalis are frequently used when drawing blood. In preparation, a tourniquet is applied. This allows arterial blood to flow, but blocks the return of venous blood. The resulting swelling makes the veins more visible and palpable.

Fig. 22.7 **Fossa cubitalis**
Right limb, anterior view. The subcutaneous veins of fossa cubitalis have a highly variable course.



A M-shaped.

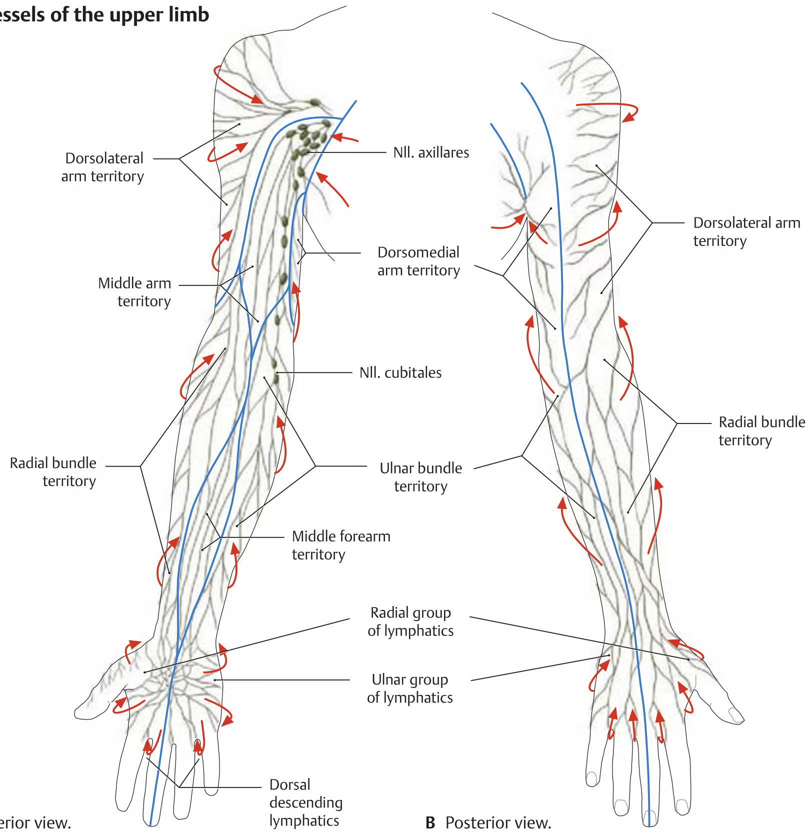
B V. cephalica accessoria.

C Absent v. mediana cubiti.

Lymph from the upper limb and breast drains to nll. axillares. The superficial lymphatics of the upper limb lie in the subcutaneous tissue, while the deep lymphatics accompany the arteries and deep veins. Numerous anastomoses exist between the two systems.

Fig. 22.8 Lymph vessels of the upper limb

Right limb.



A Anterior view. **B** Posterior view.

Fig. 22.9 Lymphatic drainage of the hand

Right hand, radial view. Most of the hand drains to nll. axillares via nll. cubitales. However, the thumb, index finger, and dorsum of the hand drain directly.

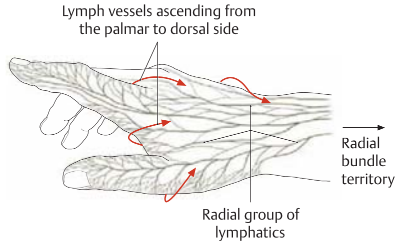
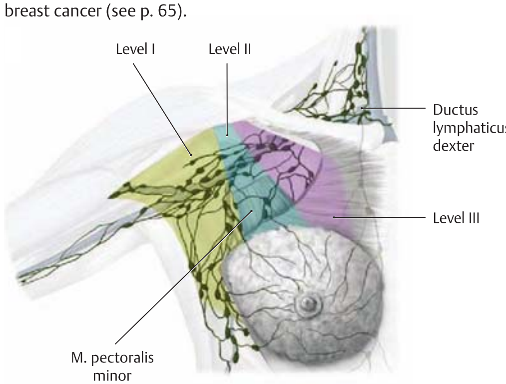


Fig. 22.10 Axillary lymph nodes

Right side, anterior view. Nll. axillares are divided into three levels with respect to m. pectoralis minor. They have major clinical importance in breast cancer (see p. 65).



Nerves of Plexus Brachialis

Almost all muscles in the upper limb are innervated by plexus brachialis, which arises from spinal cord segments C5 to T1. The anterior rami of the spinal nerves give off direct branches (pars supraclavicularis of plexus brachialis) and merge to form three trunci, six divisiones (three anterior and three posterior), and three fasciculi. The pars infraclavicularis of plexus brachialis consists of short branches that arise directly from the fasciculi and long (terminal) branches that traverse the limb.

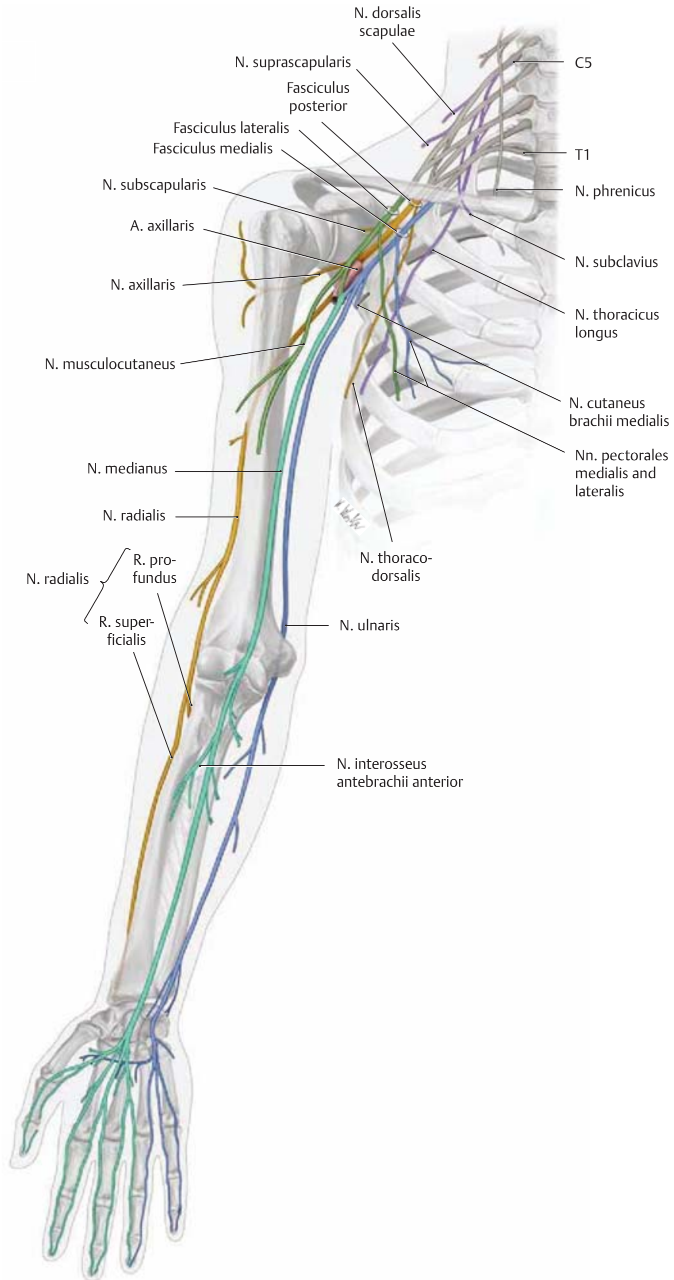
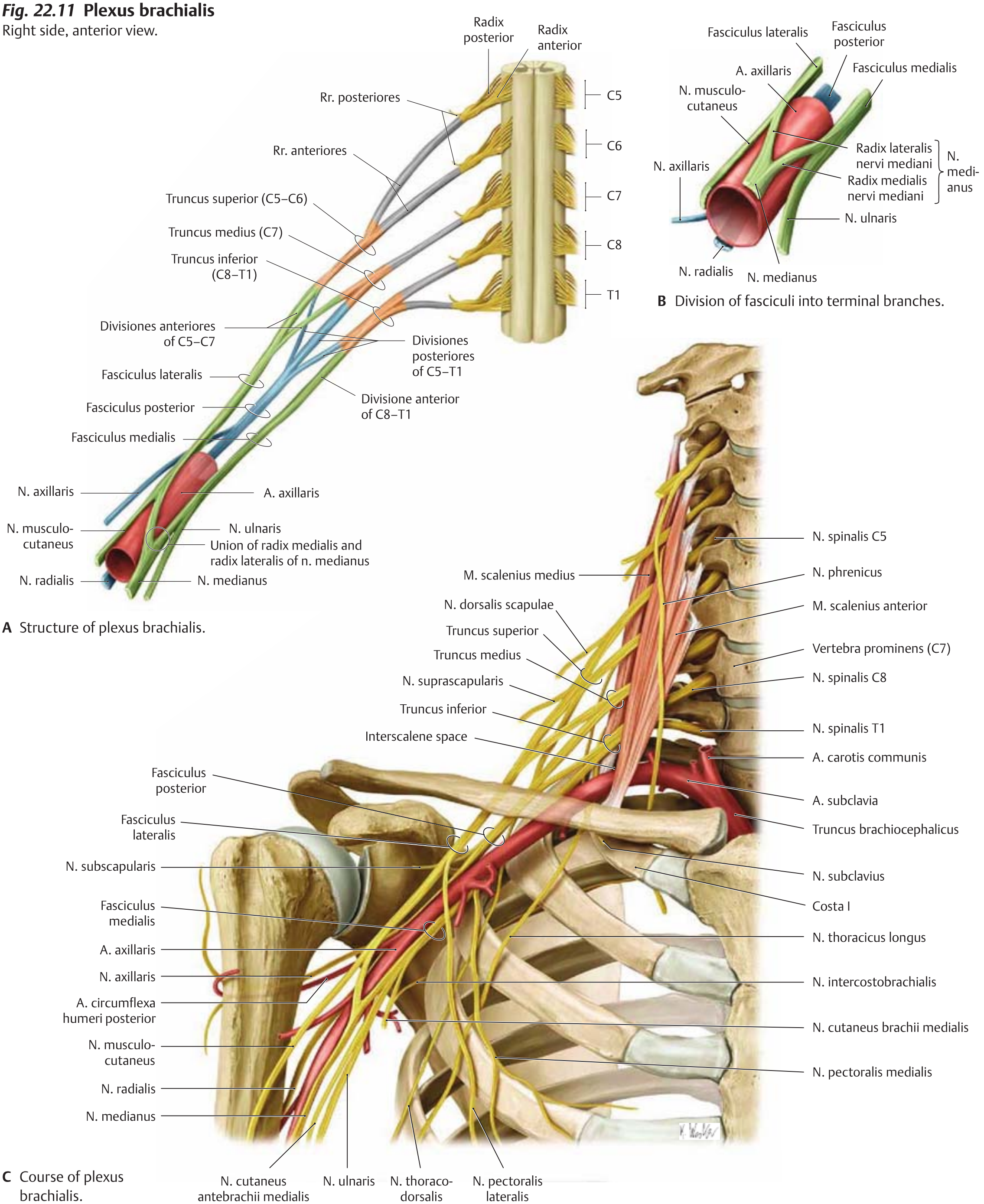


Table 22.1 Nerves of the plexus brachiales

Pars supraclavicularis				
Direct branches from the rr. anteriores or trunci plexus brachialis				
(purple)		N. dorsalis scapulae		C4–C5
		N. suprascapularis		C4–C6
		N. subclavius		C5–C6
		N. thoracicus longus		C5–C7
Pars infraclavicularis				
Short and long branches from the plexus cords				
(green)	**Fasciculus lateralis**	N. pectoralis lateralis		C5–C7
		N. musculocutaneus		
(teal)		N. medianus	Radix lateralis	C6–C7
	Fasciculus medialis		Radix medialis	C8–T1
(blue)		N. pectoralis medialis		
		N. cutaneus antebrachii medialis		
		N. cutaneus brachii medialis		T1
		N. ulnaris		C7–T1
(orange)	**Fasciculus posterior**	N. subscapular superior		C5–C6
		N. thoracodorsalis		C6–C8
		N. subscapularis inferior		C5–C6
		N. axillaris		
		N. radialis		C5–T1

Fig. 22.11 **Plexus brachialis**
Right side, anterior view.



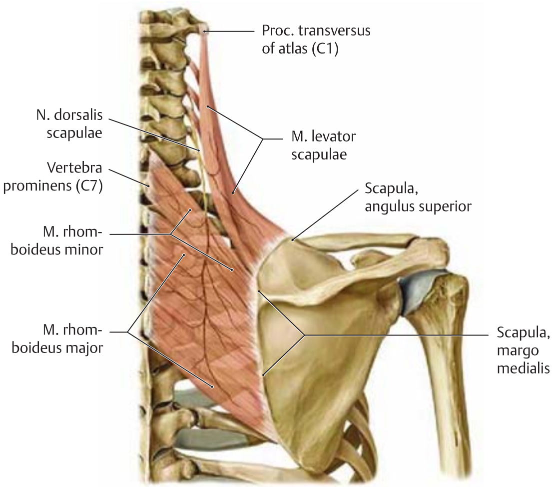
A Structure of plexus brachialis.

B Division of fasciculi into terminal branches.

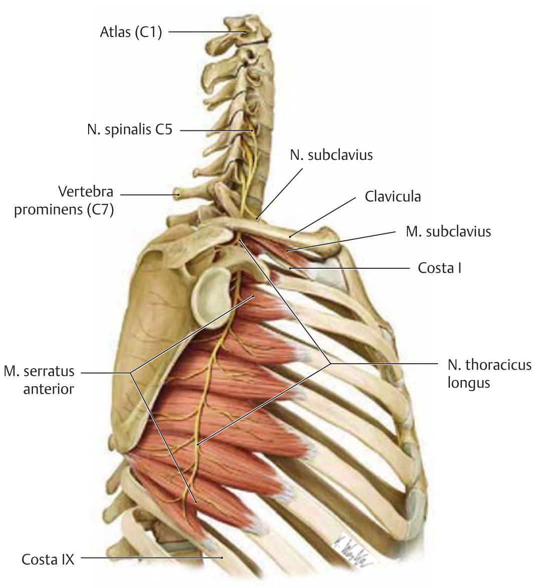
C Course of plexus brachialis.

Supraclavicular Branches & Fasciculus Posterior

Fig. 22.12 **Supraclavicular branches**
Right shoulder.

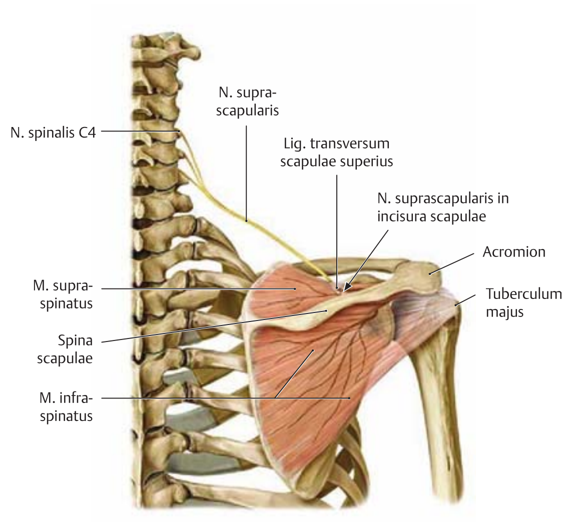


A N. dorsalis scapulae. Posterior view.



C N. thoracicus longus and n. subclavius. Right lateral view.

The supraclavicular branches of plexus brachialis arise directly from the plexus roots (anterior rami of the spinal nerves) or from the trunci in the lateral cervical triangle.



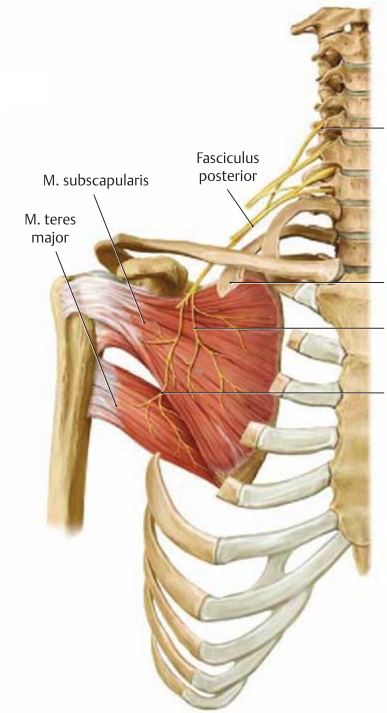
B N. suprascapularis. Posterior view.

Table 22.2 **Pars supraclavicularis**

Nerve	Level	Innervated muscle
N. dorsalis scapulae	C4–C5	M. levator scapulae M. rhomboideus major and minor
N. suprascapularis	C4–C6	M. supraspinatus M. infraspinatus
N. subclavius	C5–C6	M. subclavius Intercostobrachial nn.
N. thoracicus longus	C5–C7	M. serratus anterior

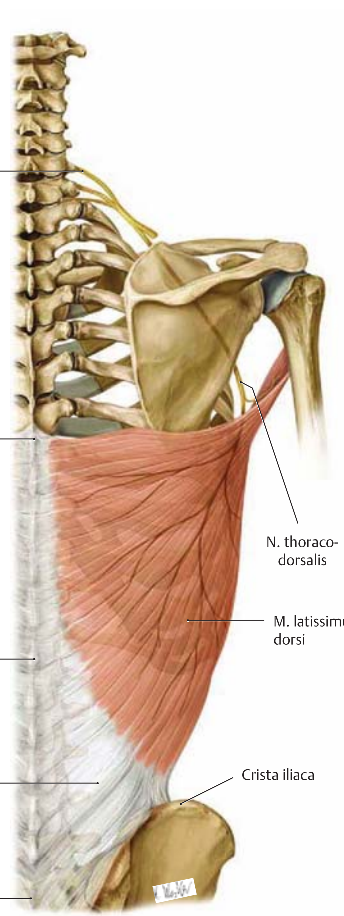
Fig. 22.13 Fasciculus posterior: Short branches

Right shoulder.



A Nn. subscapulares. Anterior view.

The fasciculus posterior gives off three short branches (arising at the level of the plexus cords) and two long branches (terminal nerves, see pp. 324–325).



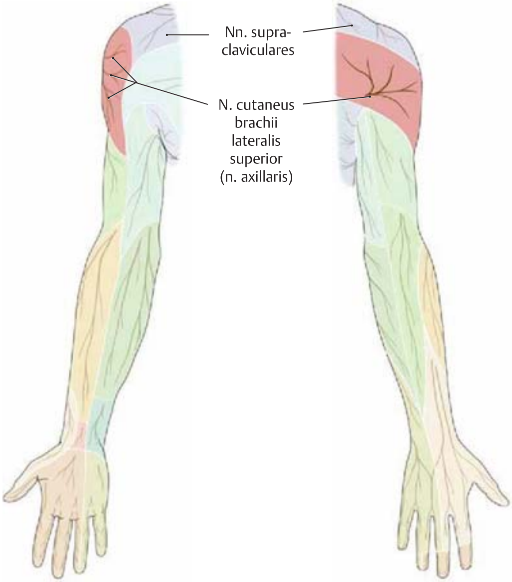
B N. thoracodorsalis. Posterior view.

Table 22.3 Branches of the fasciculus posterior

Nerve	Level	Innervated muscle
Short branches		
N. subscapularis inferior	C5–C6	M. subscapularis
N. subscapularis superior		M. subscapularis M. teres major
N. thoracodorsalis	C6–C8	M. latissimus dorsi
Long (terminal) branches		
N. axillaris	C5–C6	See p. 324
N. radialis	C5–T1	See p. 325

Fasciculus Posterior: N. Axillaris & N. Radialis

Fig. 22.14 **N. axillaris: Sensory distribution**
Right limb.



A Anterior view.

B Posterior view.

> ***Clinical***
>
> N. axillaris may be damaged in a fracture of the proximal humerus. This results in limited ability to abduct the arm, and may cause a loss of profile of the shoulder.

Fig. 22.15 **N. axillaris**
Right side, anterior view.

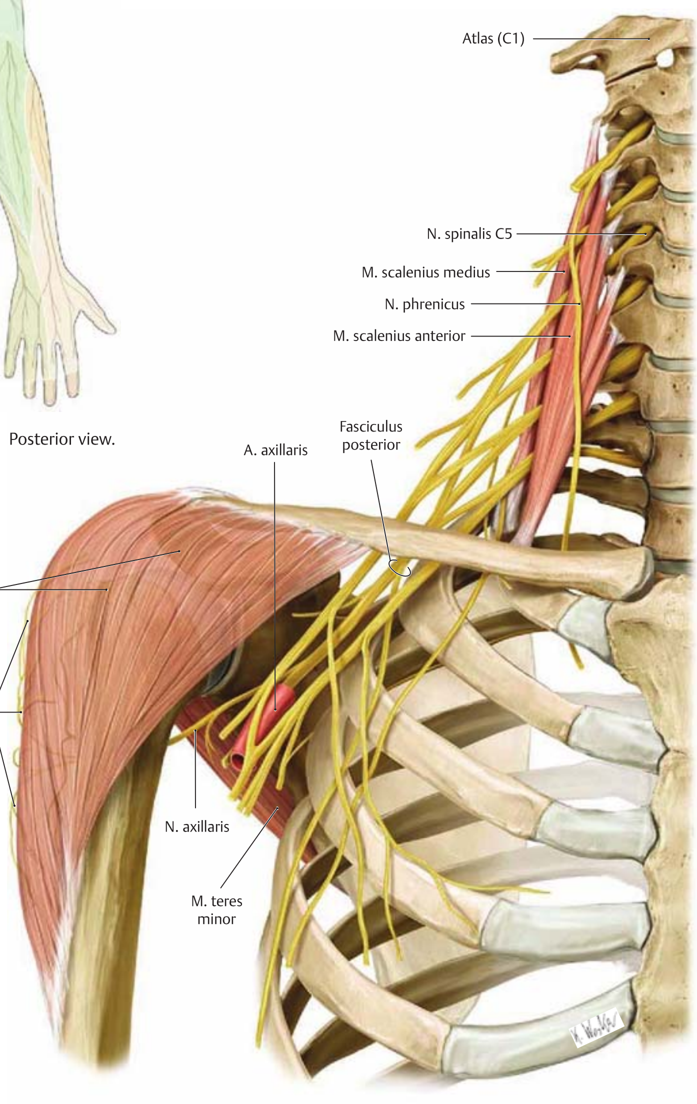
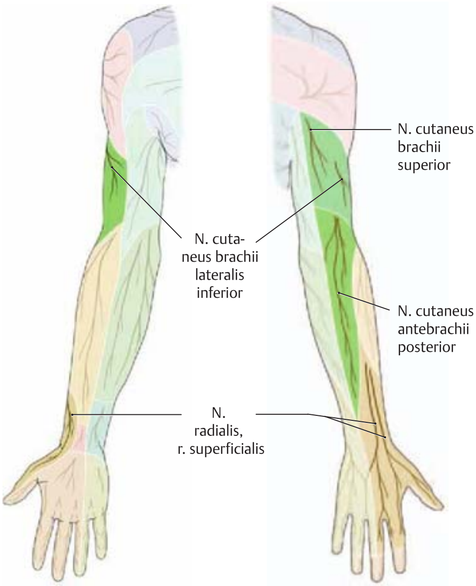


Table 22.4	**N. axilaris (C5–C6)**
Motor branches	**Innervated muscles**
Rr. musculares	M. deltoideus M. teres minor
Sensory branch	
N. cutaneus brachii lateralis superior	

Fig. 22.16 **N. radialis: Sensory distribution**



A Anterior view.

B Posterior view.

Fig. 22.17 **N. radialis**
Right limb, anterior view with forearm pronated.

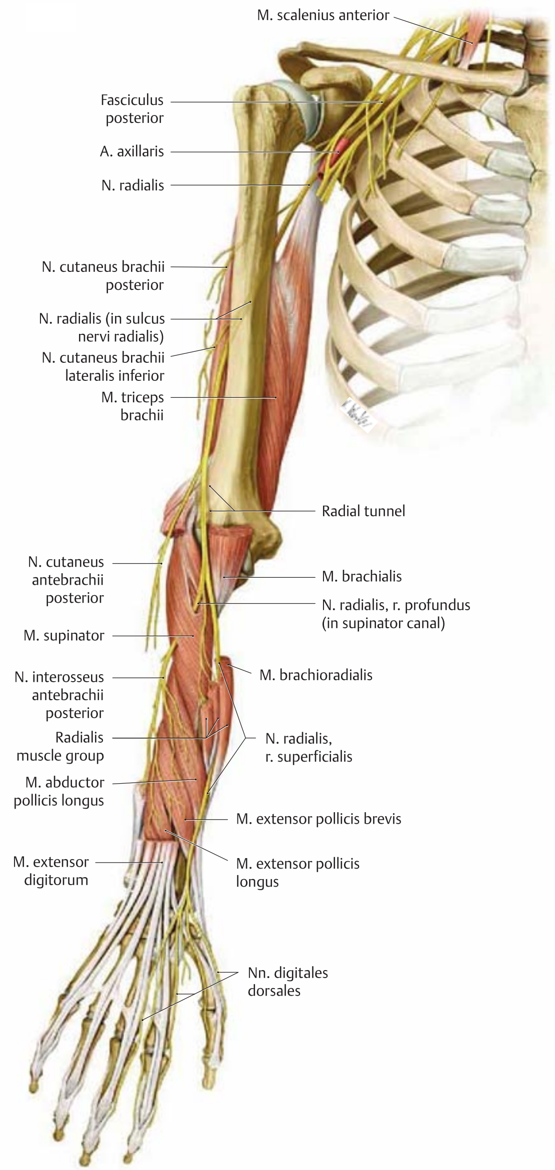


Table 22.5	**N. radialis (C5–T1)**
Motor branches	**Innervated muscles**
Rr. musculares	M. brachialis (partial)
	M. triceps brachii
	M. anconeus
	M. brachioradialis
	M. extensors carpi radialis longus and brevis
R. profundus (terminal branch : N. interosseus posterior)	M. supinator
	M. extensor digitorum
	M. extensor digiti minimi
	M. extensor carpi ulnaris
	M. extensors pollicis brevis and longus
	M. extensor indicis
	M. abductor pollicis longus
Sensory branches	
Rr. articulationes n. radialis : Capsula art. humeri	
Rr. articulationes n. interosseus posterior: Capsula art. carpalis and four articulationes metacarpophalangeales radials	
N. cutaneus brachii posterior	
N. cutaneus brachii lateralis inferior	
N. cutaneus antebrachii posterior	
Rr. superficiales	Nn. digitales dorsales
	R. ulnaris communicans

Clinical

Chronic compression of n. radialis in the axilla (e.g., due to extended/improper crutch use) may cause loss of sensation or motor function in the hand, forearm, and posterior arm. More distal injuries (e.g., during anesthesia) affect fewer muscles, potentially resulting in wrist drop with intact function of m. triceps brachii.

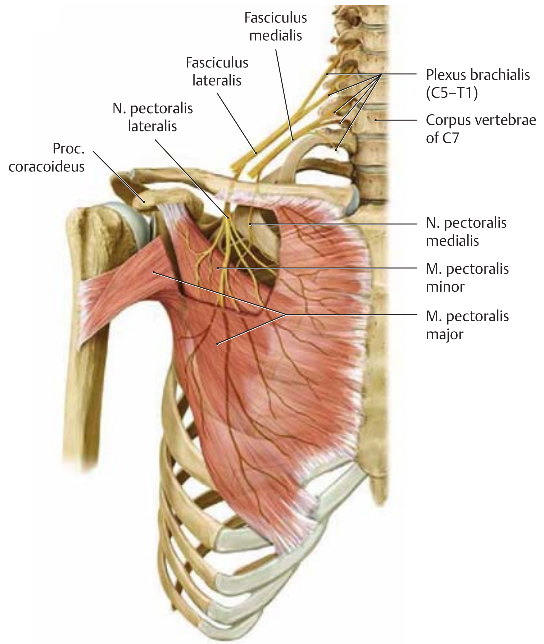
Fasciculus Medialis & Fasciculus Lateralis

The fasciculi medialis and lateralis give off four short branches. The nn. intercostobrachiales are included with the short branches of plexus brachialis, although they are actually the cutaneous branches of the 2nd and 3rd nn. intercostales.

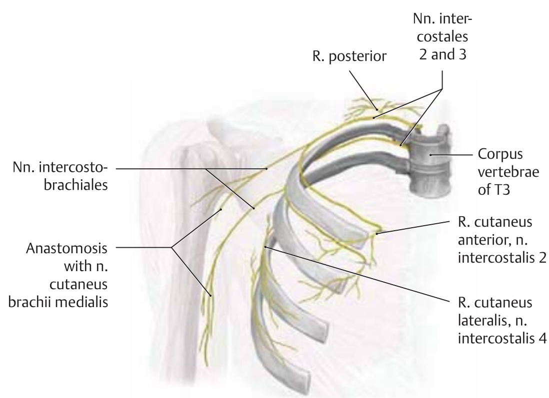
Table 22.6 Rr. fasciculus lateralis and medialis

Nerve	Level	Cord	Innervated muscle
Short branches			
N. pectoralis lateralis	C5–C7	Fasciculus lateralis	M. pectoralis major
N. pectoralis medialis	C8–T1	Fasciculus medialis	M. pectoralis major and minor
N. cutaneus brachii medialis	T1		— (sensory branches)
N. cutaneus antebrachii medialis	C8–T1		
Nn. Intercostobrachialis	T2–T3		
Long (terminal) branches			
N. musculocutaneus	C5–C7	Fasciculus lateralis	M. coracobrachialis M. biceps brachii M. brachialis
N. medianus	C6–T1	Fasciculus medialis	See p. 328
N. ulnaris	C7–T1		See p. 329

***Fig. 22.18* Fasciculi medialis and lateralis: Short branches**
Right side, anterior view.

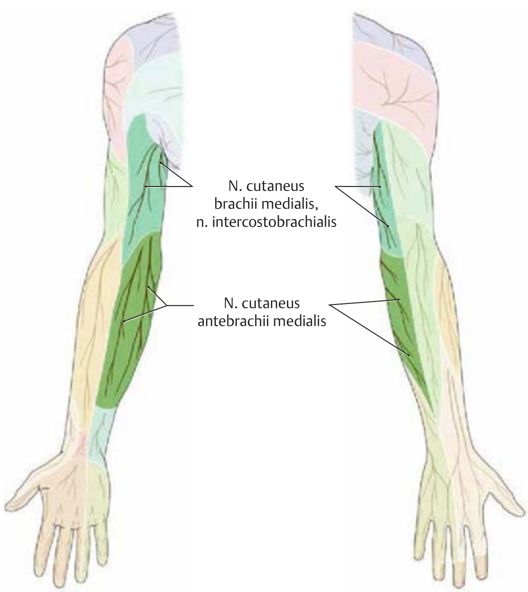


A Nn. pectorales medialis and lateralis.



B Nn. intercostobrachiales.

***Fig. 22.19* Short branches: Sensory distribution**



A Anterior view.

B Posterior view.

Fig. 22.20 **N. musculocutaneus**
Right limb, anterior view.

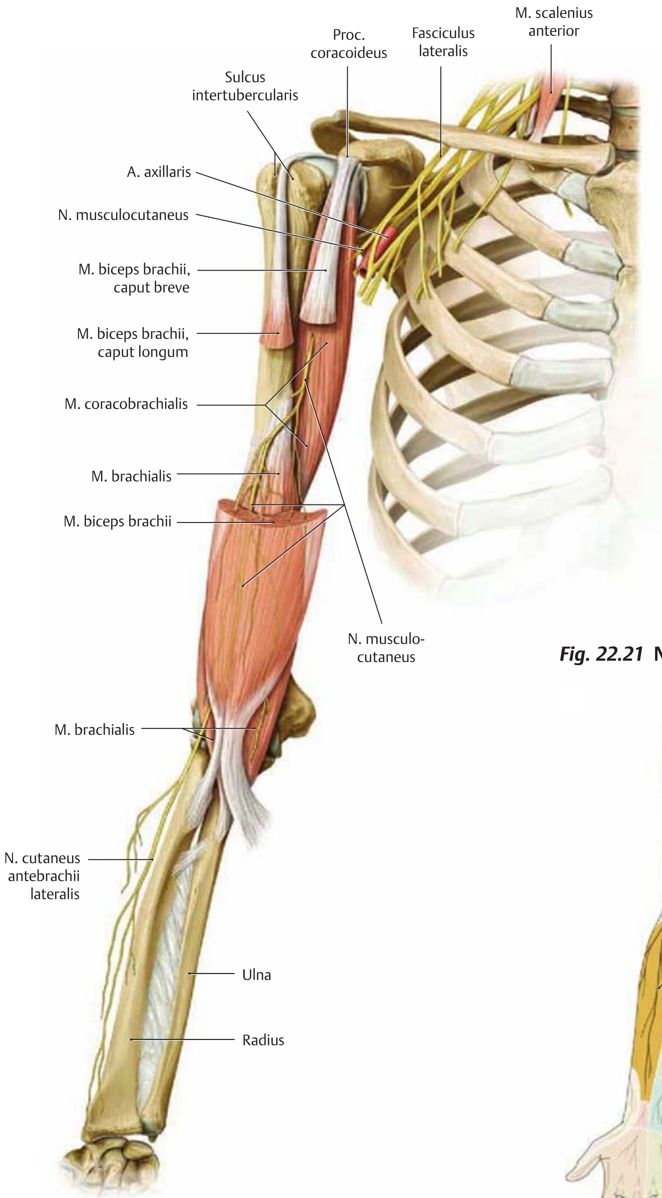
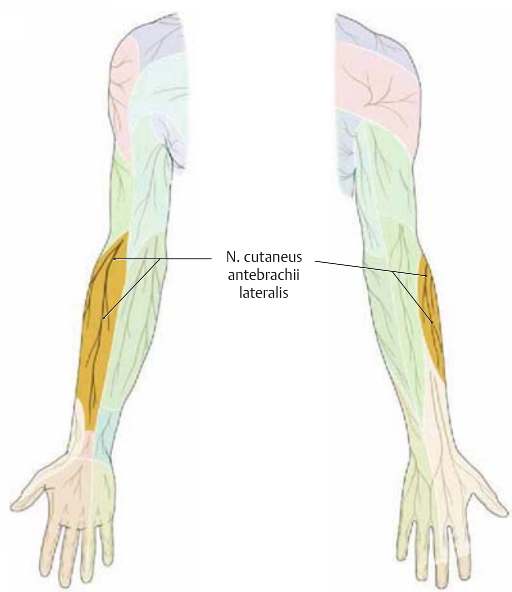


Table 22.7	**N. musculocutaneus (C5–C7)**
Motor branches	**Innervated muscles**
Rr. musculares	M. coracobrachialis
	M. biceps brachii
	M. brachialis
Sensory branches	
M. cutaneus antebrachii lateralis	
Rr. articulationes : Capsula art. cubiti (anterior part)	
Note: N. musculocutaneus nerve innervation of the arm is purely motor; innervation of the forearm is purely sensory.	

Fig. 22.21 **N. musculocutaneus: Sensory distribution**



A Anterior view. **B** Posterior view.

N. Medianus & N. Ulnaris

The n. medianus is a terminal branch arising from both fasciculus medialis and lateralis. The n. ulnaris arises exclusively from fasciculus medialis.

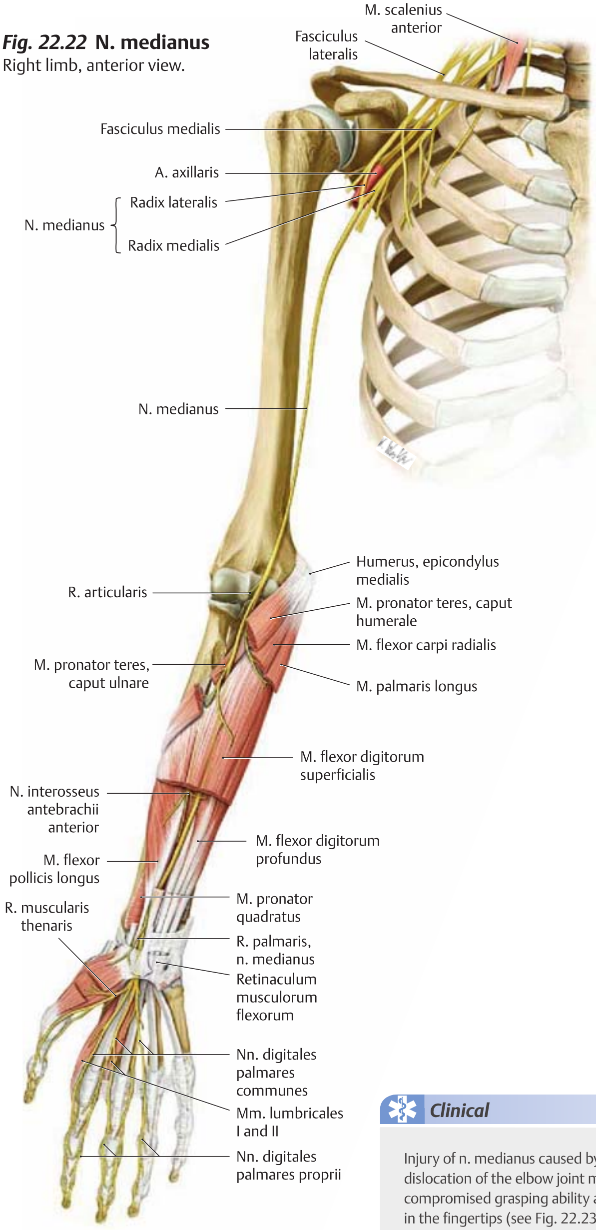


Fig. 22.22 **N. medianus**
Right limb, anterior view.

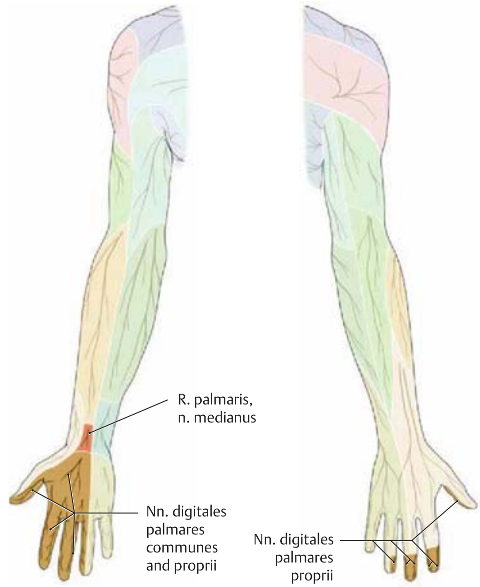


Fig. 22.23 **N. medianus: Sensory distribution**

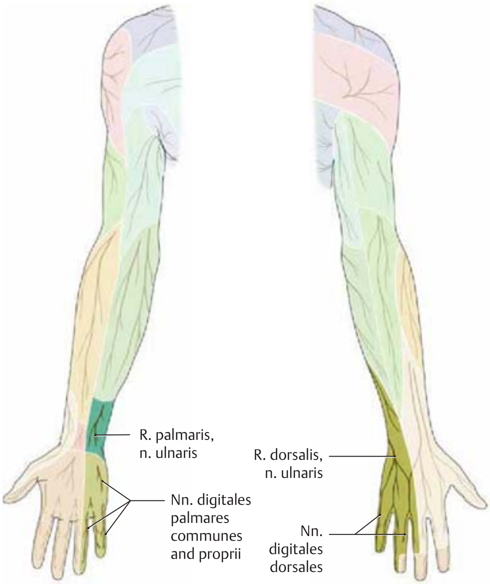
A Anterior view. **B** Posterior view.

Table 22.8	**N. medianus (C6–T1)**
Motor branches	**Innervated muscles**
Rr. musculares	M. pronator teres
	M. flexor carpi radialis
	M. palmaris longus
	M. flexor digitorum superficialis
Rr. musculares branches from N. interosseus antebrachii anterior	M. pronator quadratus
	M. flexor pollicis longus
	M. flexor digitorum profundus (radial half)
Thenar muscular branch	M. abductor pollicis brevis
	M. flexor pollicis brevis (Caput superficialis)
	M. opponens pollicis
Rr. musculares nn. digitales palmares communis	1st and 2nd lumbricals
Sensory branches	
Rr. articulations: Capsula art. cubiti and capsula art. carpalis	
R. palmaris n. medianus (thenar eminence)	
Communicating branch to ulnar n.	
Nn. digitales palmares communis	

Clinical

Injury of n. medianus caused by fracture/dislocation of the elbow joint may result in compromised grasping ability and sensory loss in the fingertips (see Fig. 22.23 for territories). See also carpal tunnel syndrome (p. 343).

Fig. 22.24 **N. ulnaris: Sensory distribution**



A Anterior view. **B** Posterior view.

Fig. 22.25 **N. ulnaris**
Right limb, anterior view.

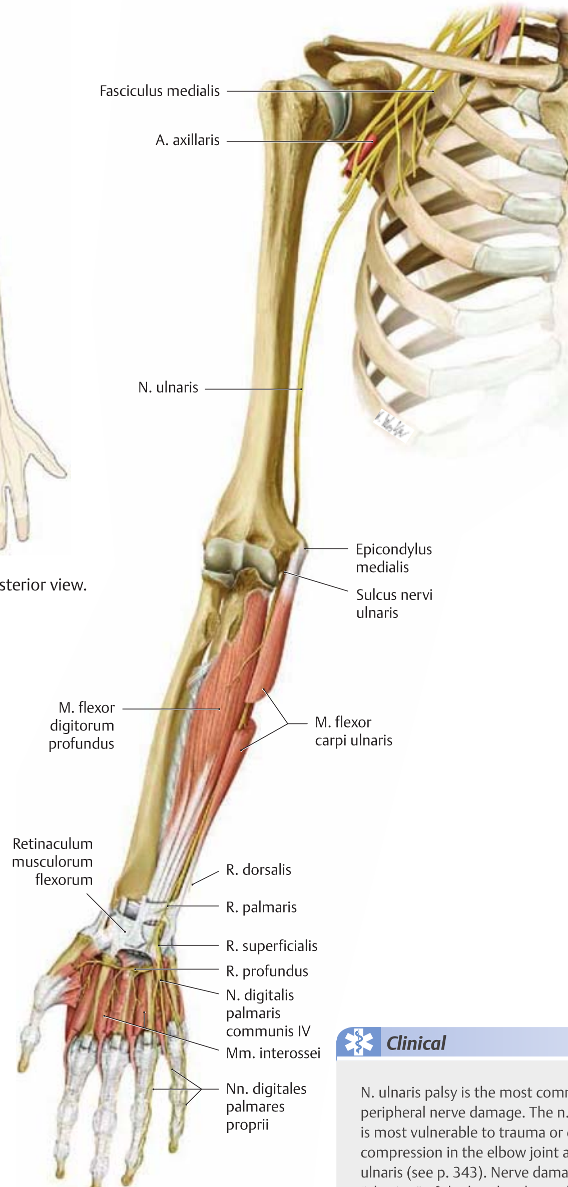


Table 22.9 **N. ulnaris (C7–T1)**

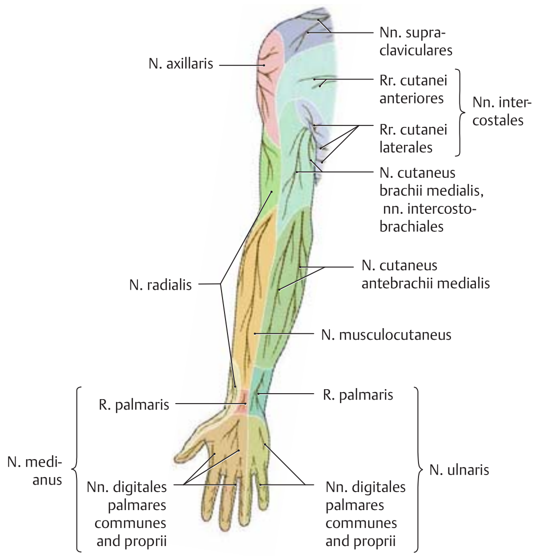
Motor branches	Innervated muscles
Rr. musculares	M. flexor carpi ulnaris
	M. flexor digitorum profundus (ulnar half)
R. muscularis n. ulnaris superior	M. palmaris brevis
Rr. musculares n. ulnaris profundus	M. abductor digiti minimi
	M. flexor digiti minimi
	M. opponens digiti minimi
	3rd and 4th lumbricals
	M. palmaris and m. interosseus dorsalis
	M. adductor pollicis
	M. flexor pollicis brevis (caput profundus)
Sensory branches	
Rr. articulations: Capsula art. cubiti, capsula art. carpalis and art. metacarpophalangealis	
R. dorsales (terminal branches: Nn. digitales dorsales)	
R. palmaris n.ulnaris	
Nn. digitales palmares proprii (from r.superficialis)	
N. digitalis palmaris communis (from r. superficialis; terminal branches: Nn. digitales palmaris proprii)	

Clinical

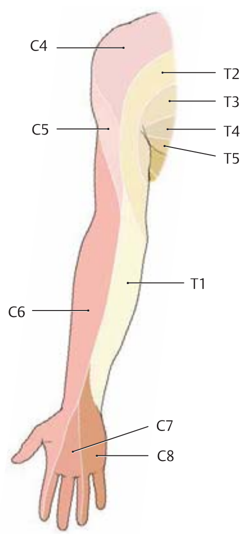
N. ulnaris palsy is the most common peripheral nerve damage. The n. ulnaris is most vulnerable to trauma or chronic compression in the elbow joint and canalis ulnaris (see p. 343). Nerve damage causes “clawing” of the hand and atrophy of mm. interossei. Sensory losses are often limited to the 5th digit.

Superficial Veins & Nerves of the Upper Limb

Fig. 22.26 **Cutaneous innervation of the upper limb: Anterior view**

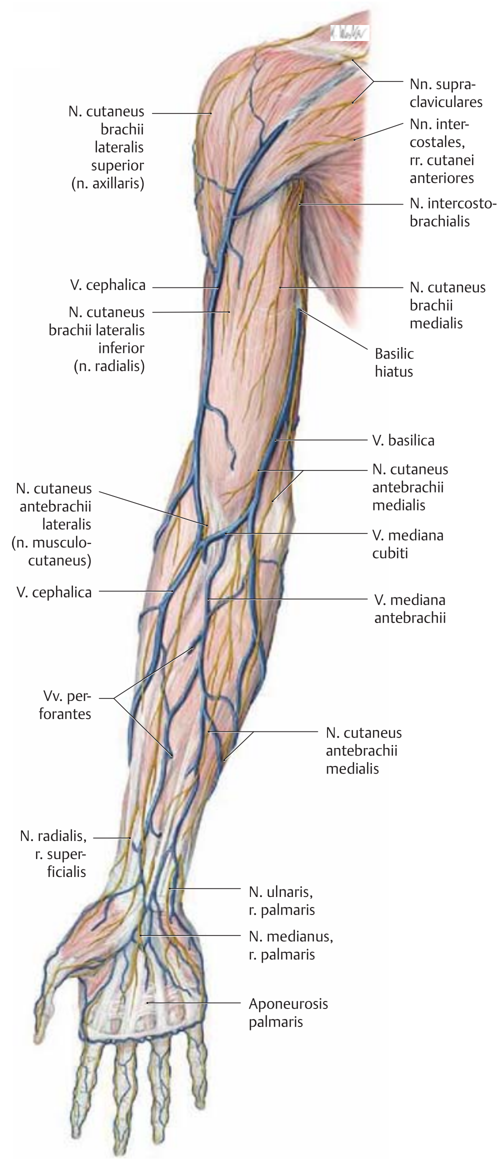


A Peripheral sensory cutaneous innervation.

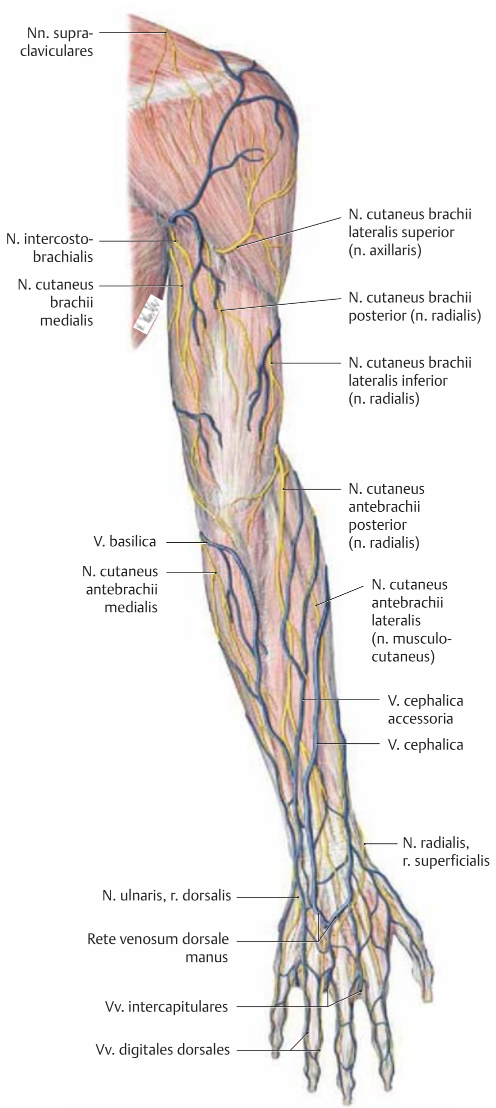


B Segmental, radicular cutaneous innervation (dermatomes).

Fig. 22.27 **Superficial cutaneous veins and nerves of the upper limb**

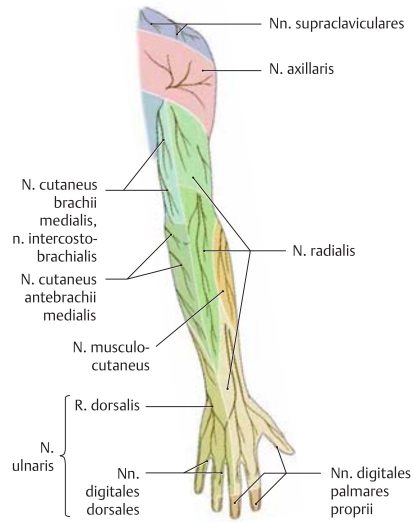


A Anterior view. See p. 344 for nerves of the palm.

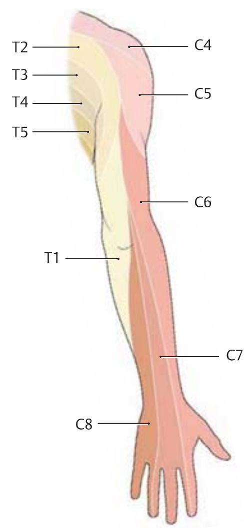


B Posterior view. See p. 346 for nerves of the dorsum.

Fig. 22.28 Cutaneous innervation of the upper limb: Posterior view



A Peripheral sensory cutaneous innervation.



B Segmental, radicular cutaneous innervation (dermatomes).

Posterior Shoulder & Axilla

Fig. 22.29 **Posterior shoulder**
Right shoulder, posterior view. *Raised:* M. trapezius (pars transversa). *Windowed:* M. supraspinatus. *Revealed:* Suprascapular region.

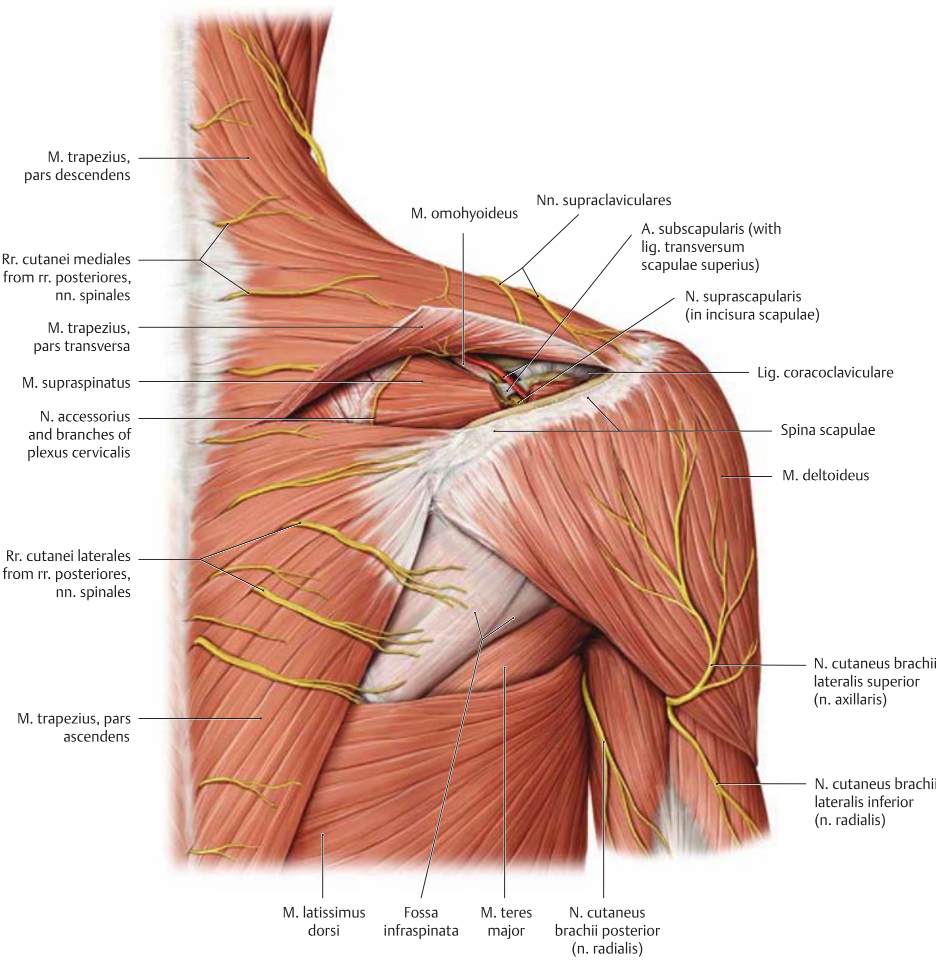


Table 22.10 Neurovascular tracts of the scapula

	Passageway	Boundaries	Transmitted structures
①	Scapular notch	Lig. transversum scapulae superius, scapula	A. and n. suprascapularis
②	Medial border	Scapula	A. and n. scapularis dorsalis
③	Triangular space	M. teres major and minor	A. circumflexa scapulae
④	Triceps hiatus	M. triceps brachii, m. humerus, m. teres major	A. profunda brachii and n. radialis
⑤	Quadrangular space	M. teres major and minor, m. triceps brachii, m. humerus	A. circumflexa humeri posterior and n. axilaris

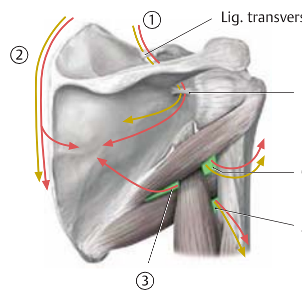
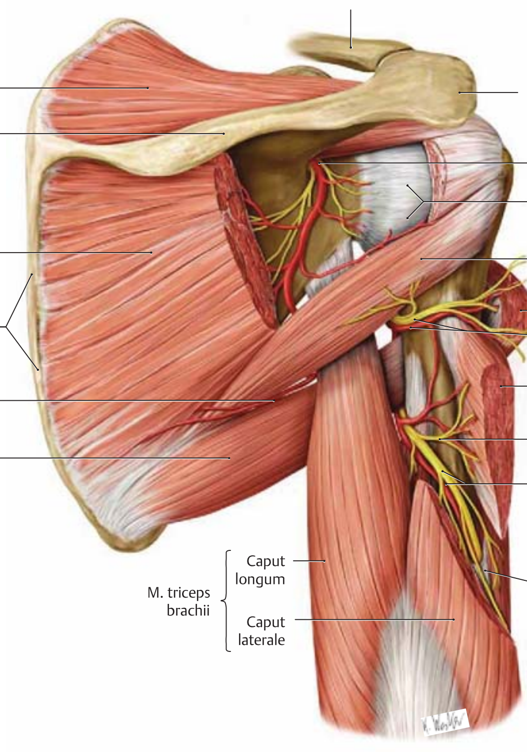
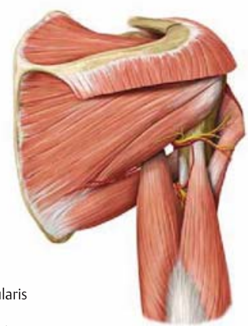


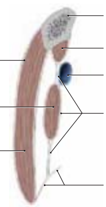
Fig. 22.30 **Axilla: Spatium axillare mediale and laterale**
Right shoulder, posterior view.



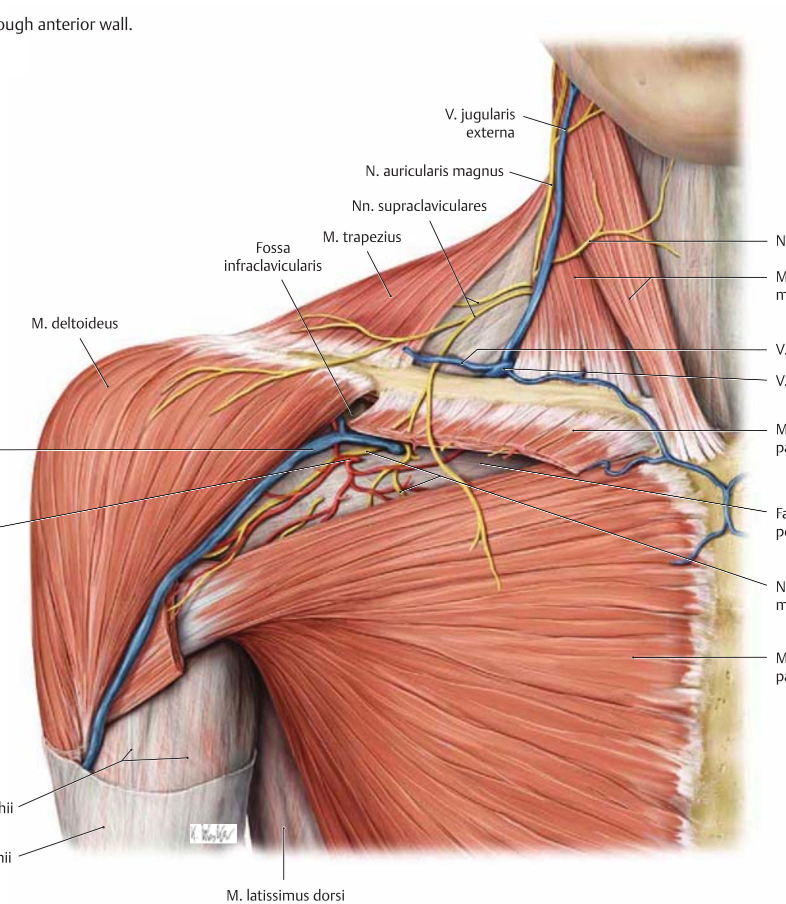


Anterior Shoulder

Fig. 22.31 **Anterior shoulder: Superficial dissection**
Right shoulder.



A Sagittal section through anterior wall.



B Anterior view. *Removed:* Platysma, muscle fasciae, superficial layer of fascia cervicalis, and m. pectoralis major (clavicular part). *Revealed:* Trigonum clavipectorale (deltopectorale).

Fig. 22.32 **Shoulder: Transverse section**
Right shoulder, inferior view.

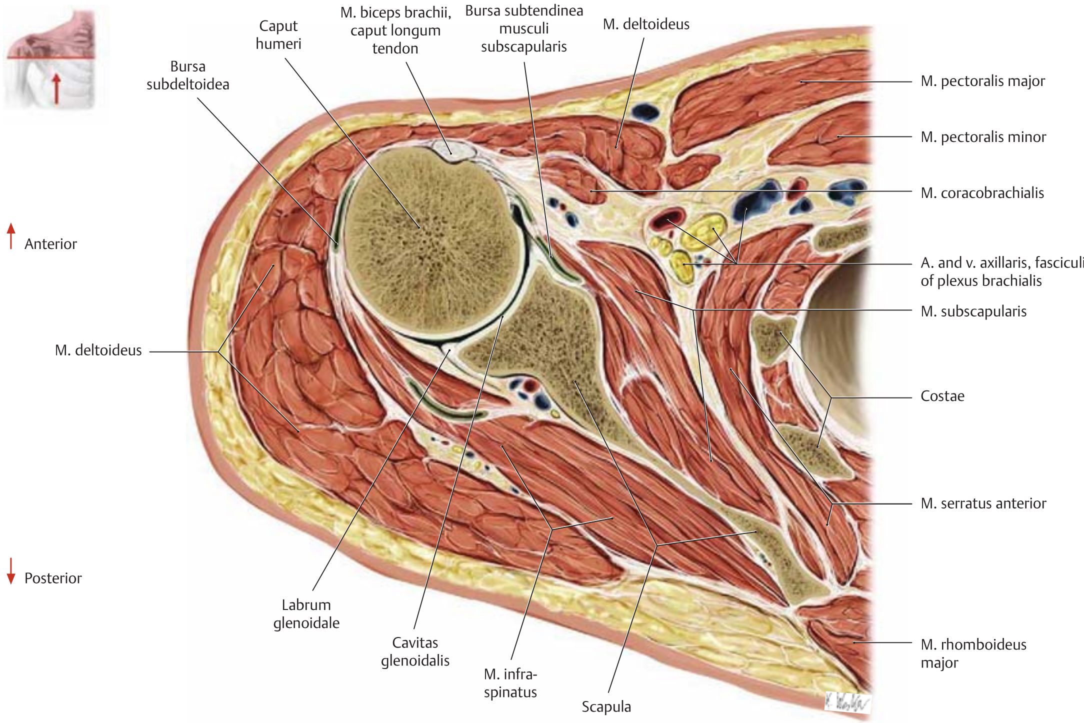
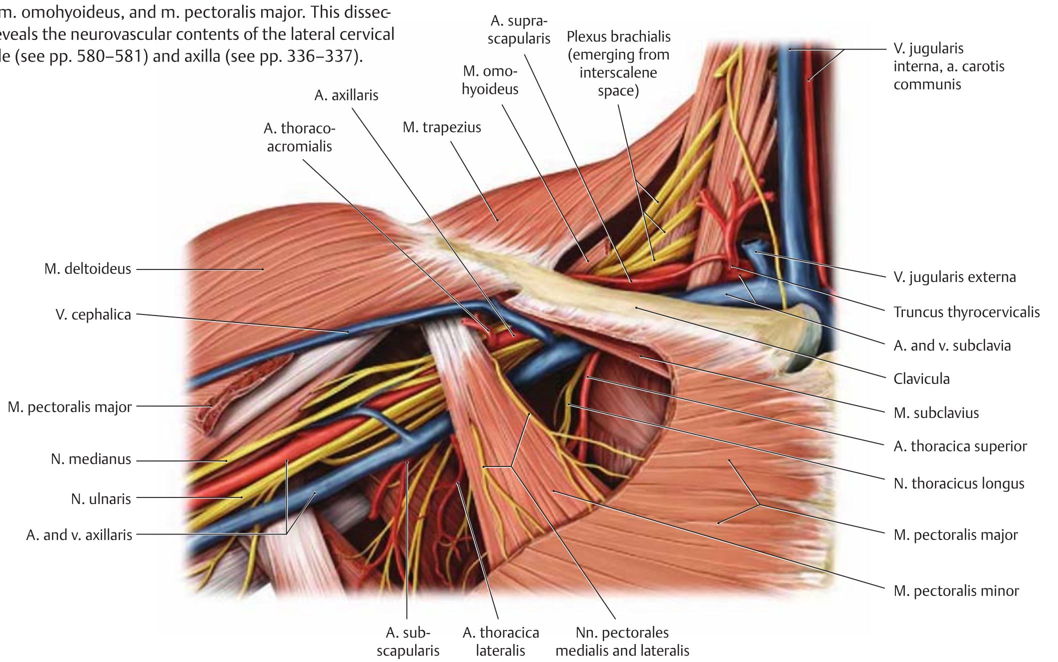
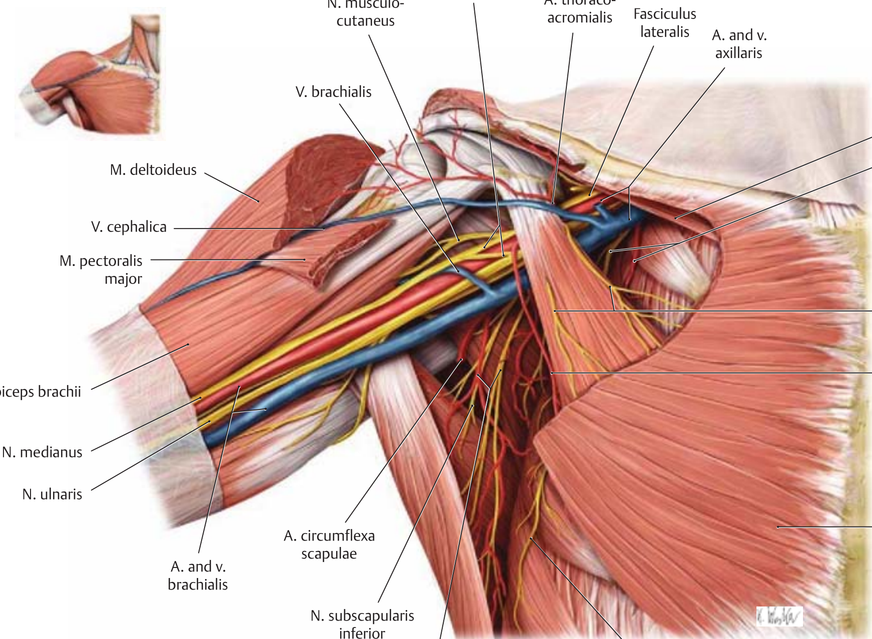


Fig. 22.33 **Anterior shoulder: Deep dissection**
Right limb, anterior view. *Removed:* M. sternocleidomastoideus, m. omohyoideus, and m. pectoralis major. This dissection reveals the neurovascular contents of the lateral cervical triangle (see pp. 580–581) and axilla (see pp. 336–337).



Topography of the Axilla

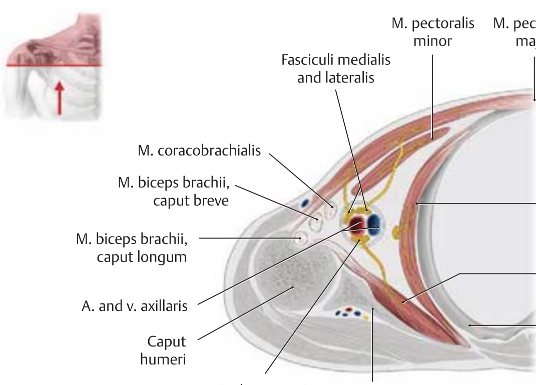
Fig. 22.34 Dissection of the axilla
Right shoulder, anterior view.

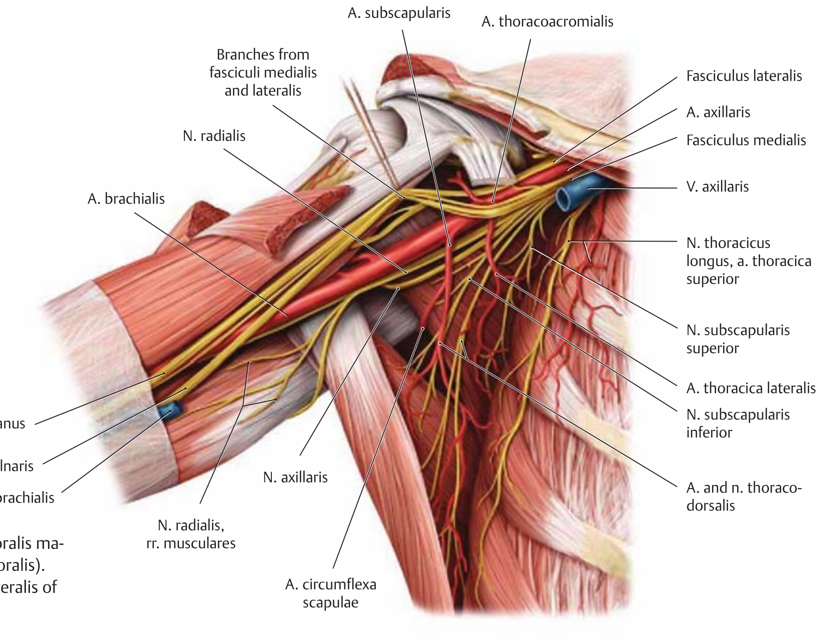


A *Removed:* M. pectoralis major and fascia clavipectoralis.

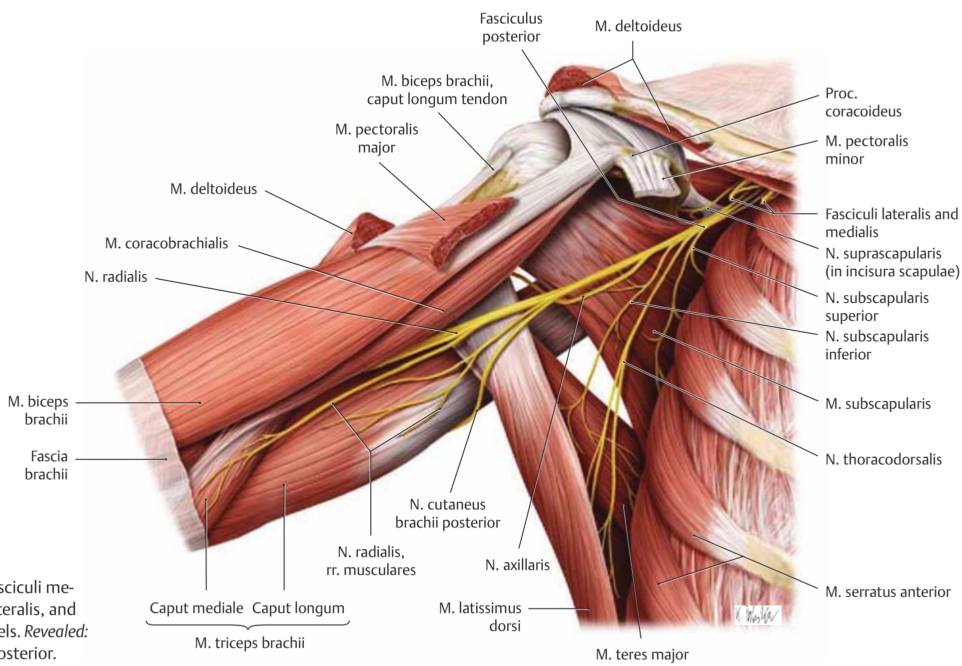
Table 22.11 Fossa axillis

Anterior wall	M. pectoralis major M. pectoralis minor Fascia clavipectoralis
Lateral wall	Intertubercular groove of humerus
Posterior wall	M. subscapularis M. teres major M. latissimus dorsi
Medial wall	Lateral thoracic wall M. serratus anterior





B *Removed:* Anterior wall (mm. pectoralis major and minor, and fascia clavipectoralis). *Retracted:* Fasciculi medialis and lateralis of plexus brachialis.



C *Removed:* Fasciculi medialis and lateralis, and axillary vessels. *Revealed:* Fasciculus posterior.

Topography of the Brachial & Cubital Regions

Fig. 22.35 **Brachial region**
Right arm, anterior view. *Removed:* M. deltoideus, mm. pectoralis major and minor. *Revealed:* Sulcus bicipitalis medialis.

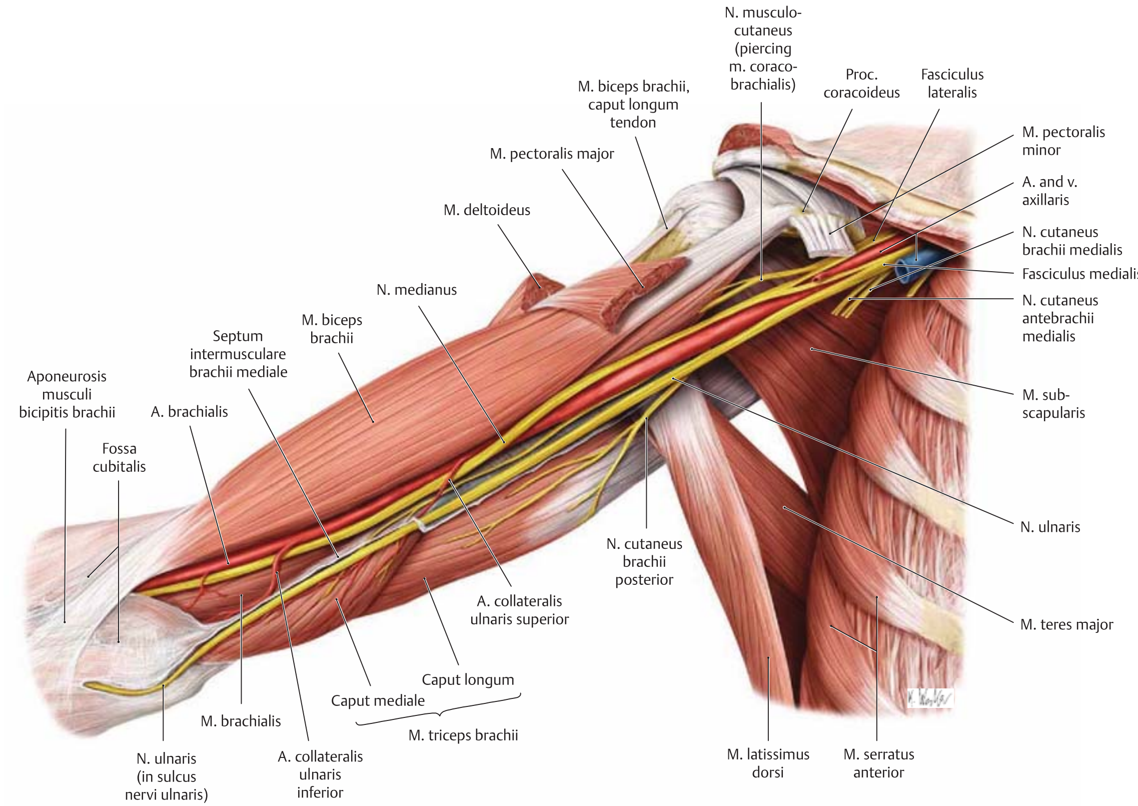
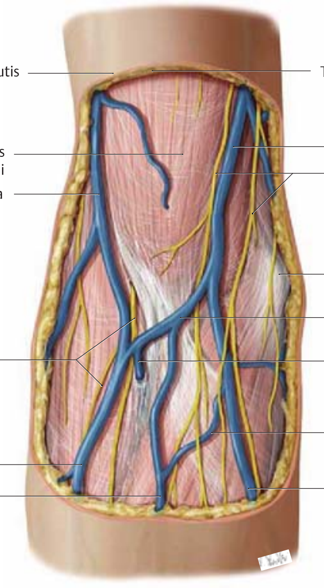
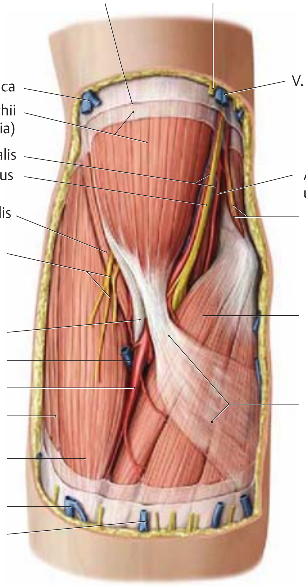


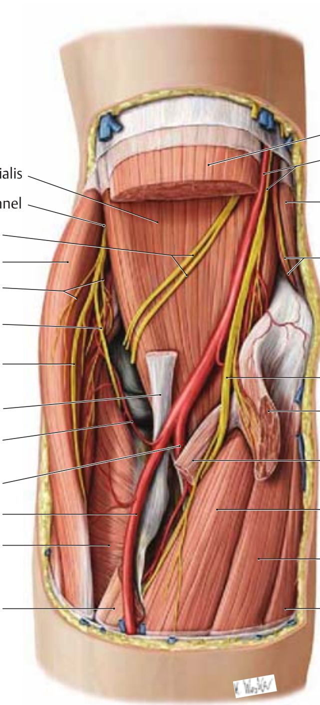
Fig. 22.36 Fossa cubitalis
Right elbow, anterior view.



A Cutaneous neurovascular structures in fossa cubitalis.



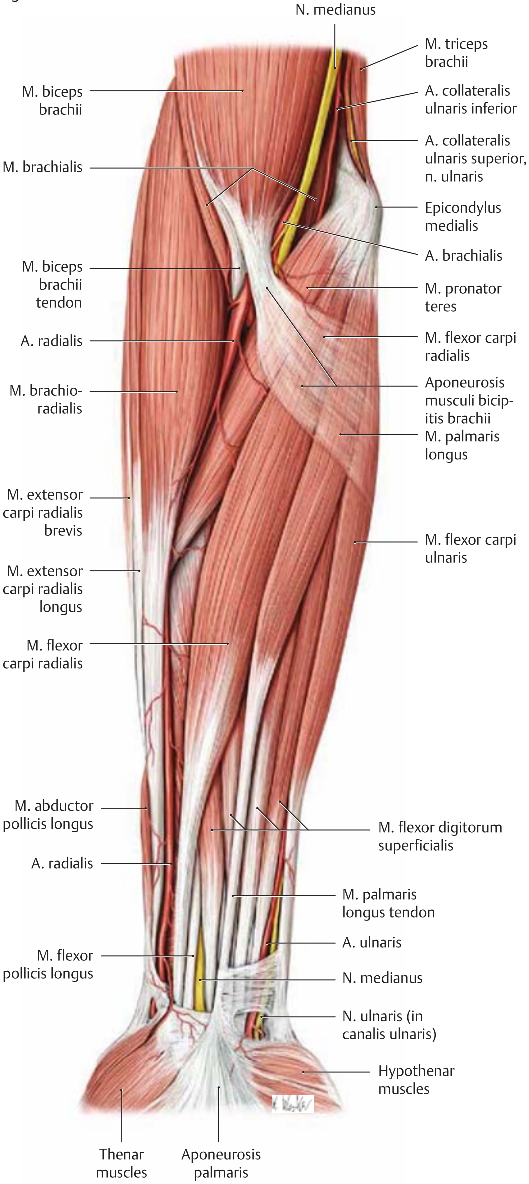
B Superficial part of fossa cubitalis. *Removed:* Fasciae and epifascial neurovascular structures.



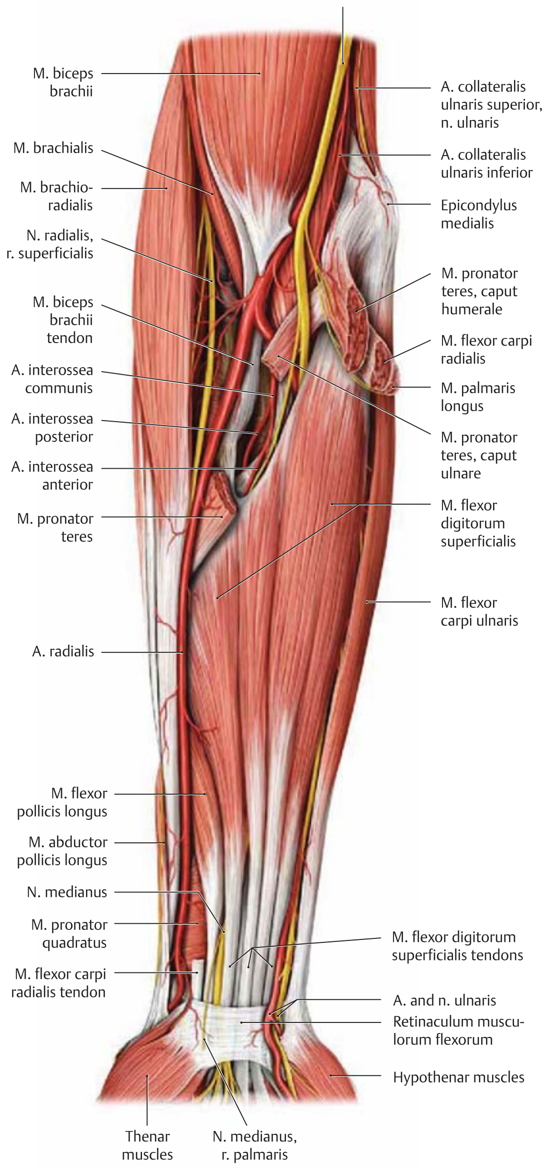
C Deep part of fossa cubitalis. *Removed:* M. biceps brachii (distal muscle belly). *Retracted:* M. brachioradialis.

Topography of the Forearm

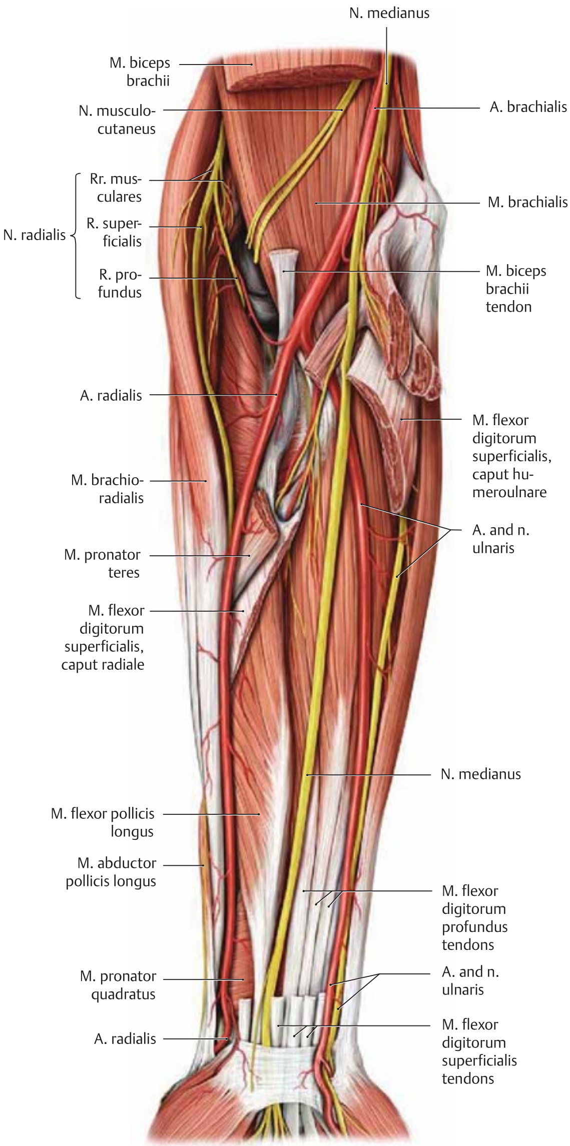
Fig. 22.37 **Anterior forearm**
Right forearm, anterior view.



A Superficial layer. *Removed:* Fasciae and superficial neurovasculature.



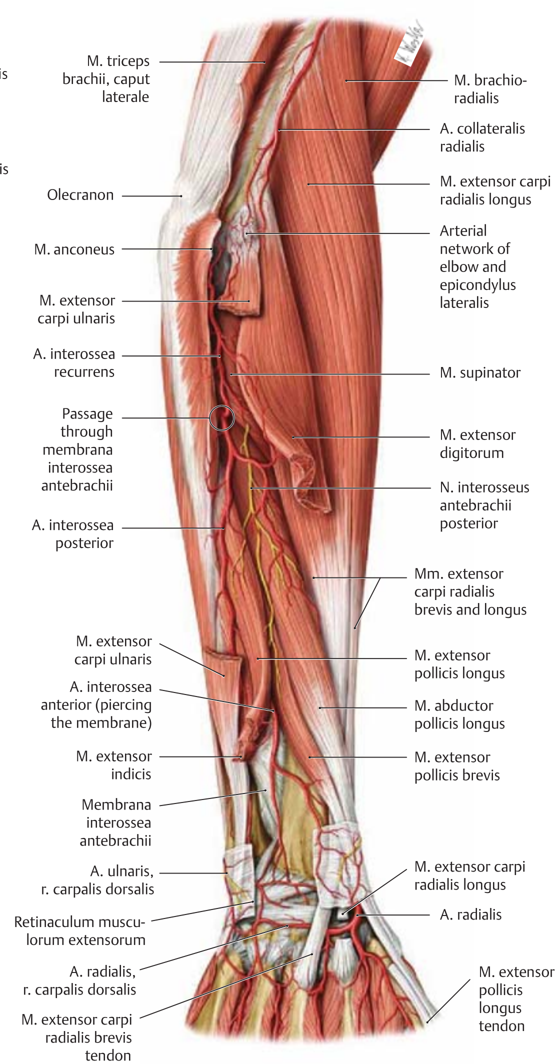
B Middle layer. *Partially removed:* Superficial flexors (m. pronator teres, m. palmaris longus, and m. flexor carpi radialis).



C Deep layer. *Removed:* Superficial flexors.

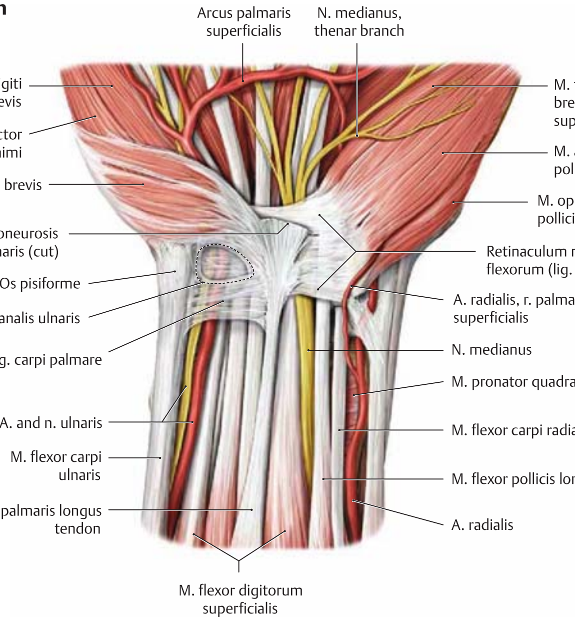
Fig. 22.38 **Posterior forearm**

Right forearm, anterior view during pronation. *Reflected:* M. anconeus and m. triceps brachii. *Resected:* M. extensor carpi ulnaris and m. extensor digitorum.

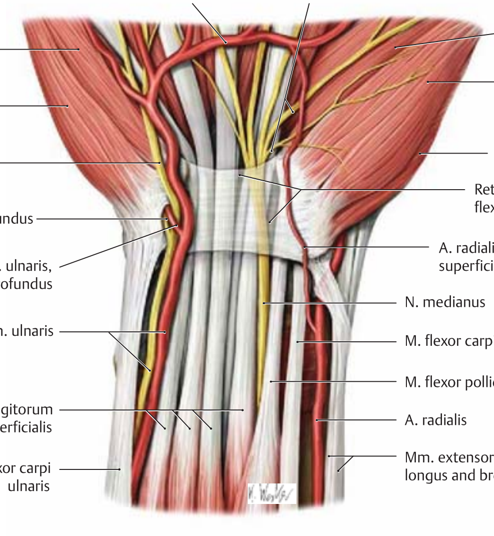


Topography of the Carpal Region

***Fig. 22.39* Anterior carpal region**
Right hand, anterior (palmar) view.



A Canalis ulnaris and deep palm.

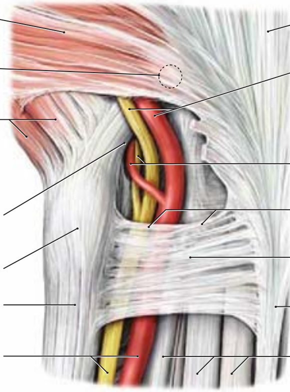


B Canalis carpi with retinaculum musculorum flexorum windowed.

Fig. 22.40 Canalis ulnaris

Right hand, anterior (palmar) view.

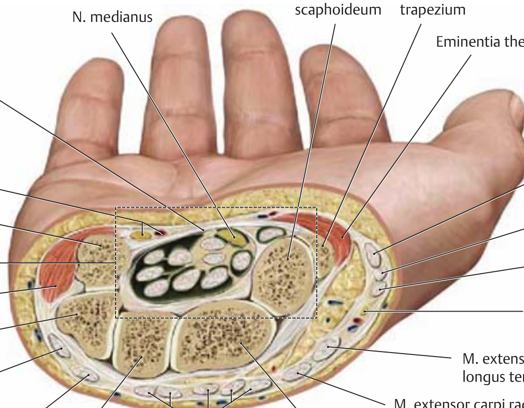
A Bony landmarks.



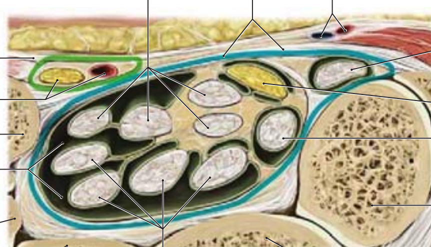
B Apertures and walls of canalis ulnaris.

Fig. 22.41 Canalis carpi: Cross section

Right hand, proximal view. The tight fit of sensitive neurovascular structures with closely apposed, frequently moving tendons in canalis carpi often causes problems (carpal tunnel syndrome) when any of the structures swell or degenerate.



A Cross section through the right wrist.

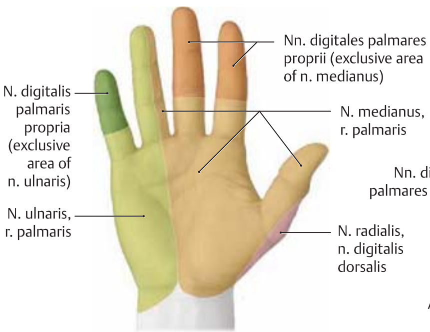


B Structures in canalis ulnaris (green) and canalis carpi (blue).

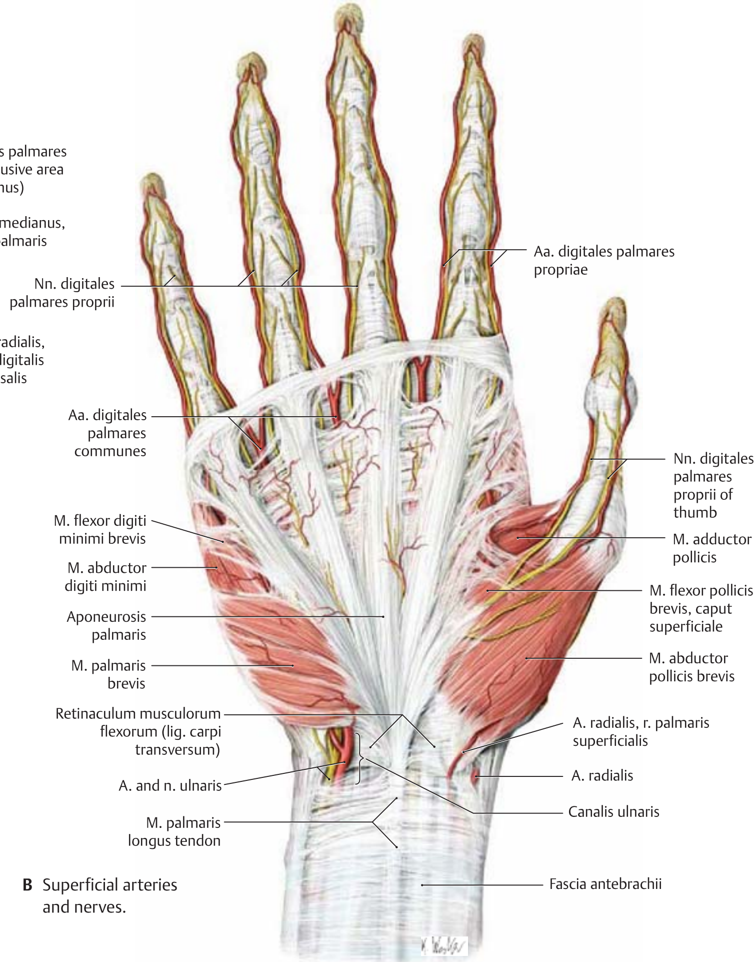
Topography of the Palm of the Hand

Fig. 22.42 Superficial neurovascular structures of the palm

Right hand, anterior view.



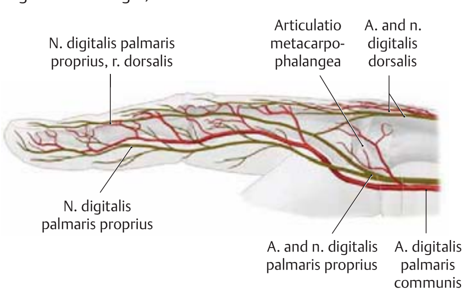
A Sensory territories. Extensive overlap exists between adjacent areas. *Exclusive* nerve territories indicated with darker shading.



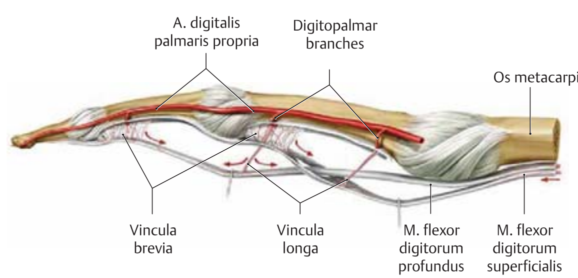
B Superficial arteries and nerves.

Fig. 22.43 Neurovasculature of the finger

Right middle finger, lateral view.

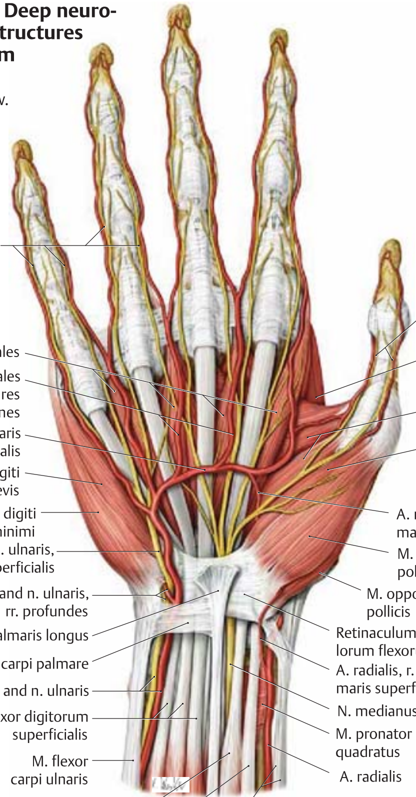


A Nerves and arteries.

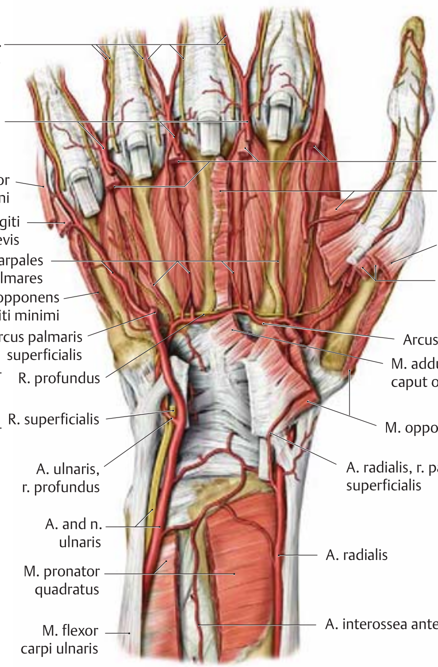


B Blood supply to the flexor tendons in the tendon sheath.

Fig. 22.44 Deep neurovascular structures of the palm
Right hand, anterior view.



A Arcus palmaris superficialis.



B Arcus palmaris profundus.

Fig. 22.45 Innervation patterns in the palm
Right hand, anterior view.

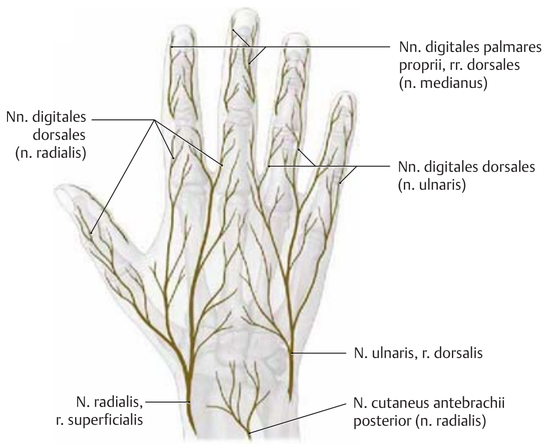
A Ulnar communicating branch (45% of cases).

B Median and ulnar communicating branches (20%).

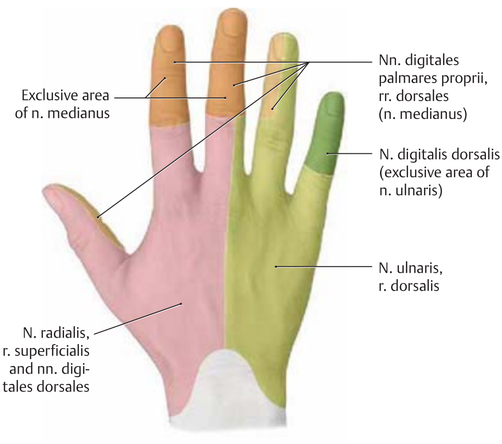
C No communicating branches (20%).

Topography of the Dorsum of the Hand

Fig. 22.46 Sensory innervation of the dorsum
Right hand, posterior view.



A Nerves of the dorsum.



B Sensory territories. Extensive overlap exists between adjacent areas. *Exclusive* nerve territories indicated with darker shading.

Fig. 22.47 Anatomic snuffbox
Right hand, radial view. The three-sided "anatomic snuffbox" [fovea radialis (Tabatière)] is bounded by the tendons of m. abductor pollicis longus and mm. extensors pollicis brevis and longus.

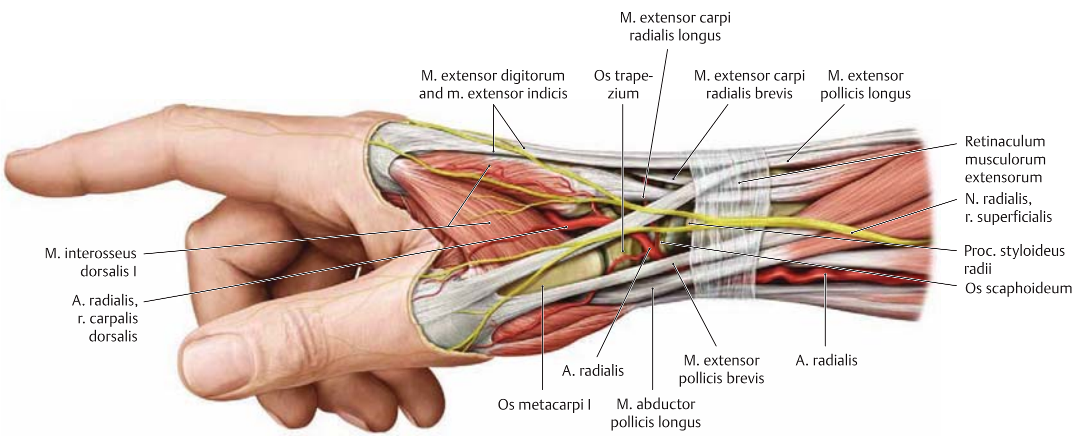
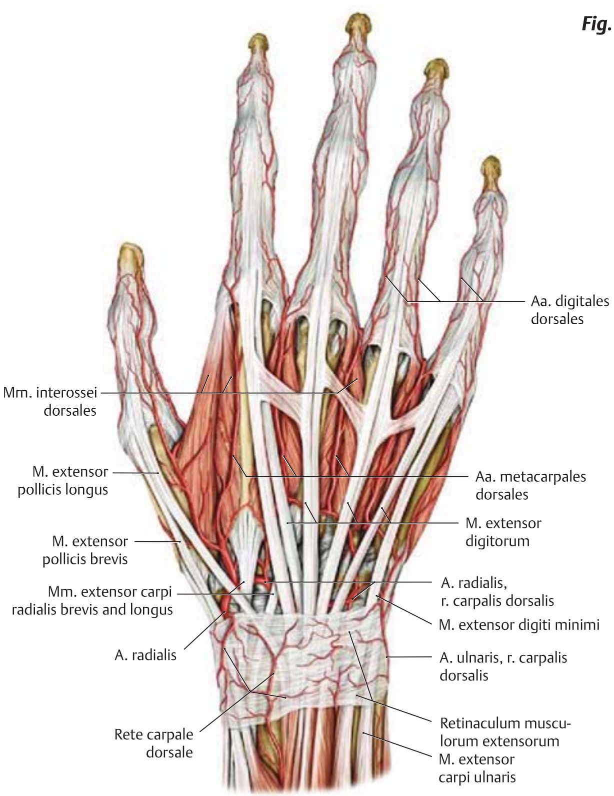
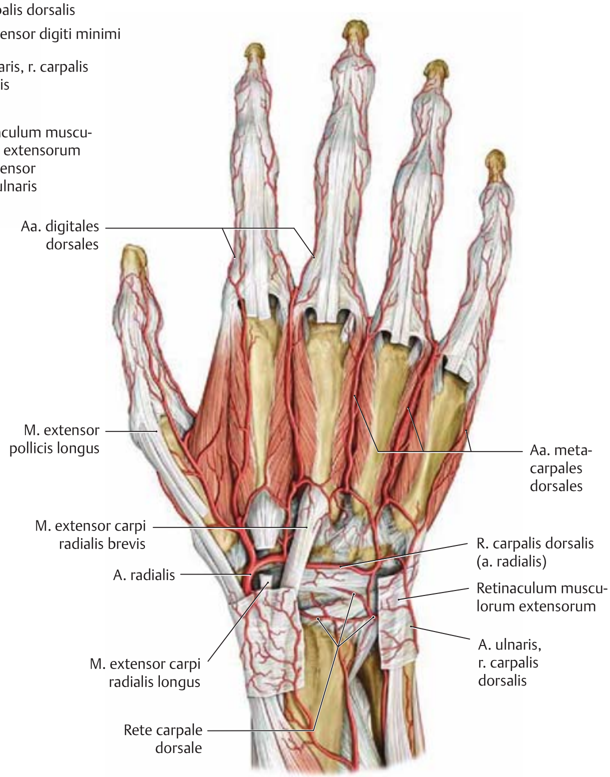


Fig. 22.48 **Neurovascular structures of the dorsum**

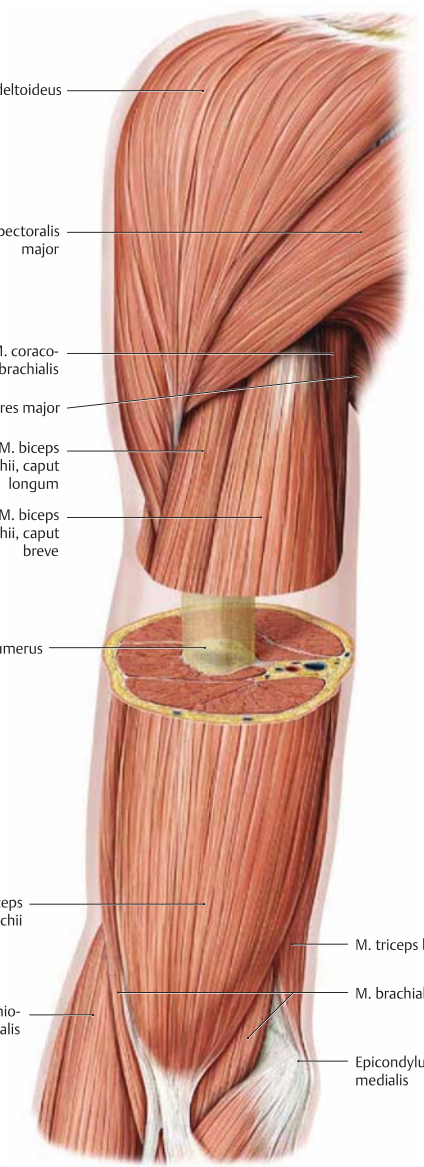


A Superficial structures.

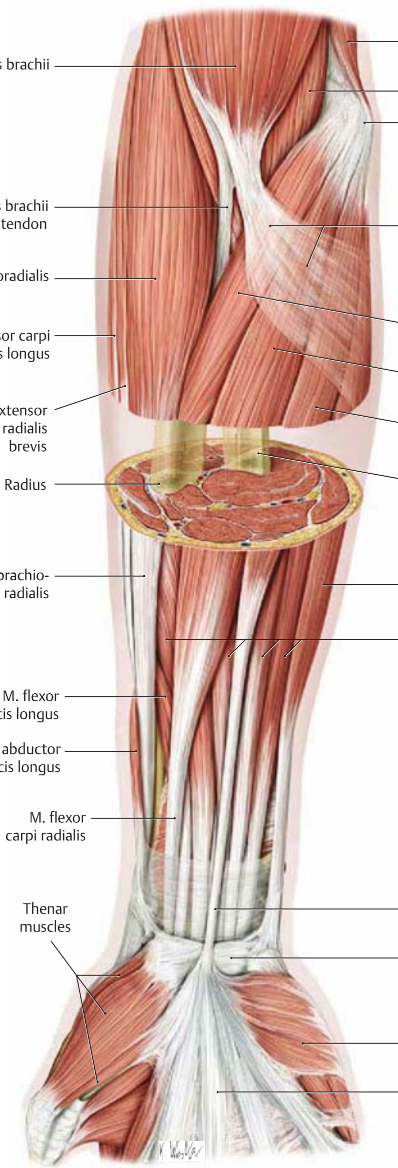


B Deep structures.

Fig. 22.49 Windowed dissection
Right limb, anterior view.

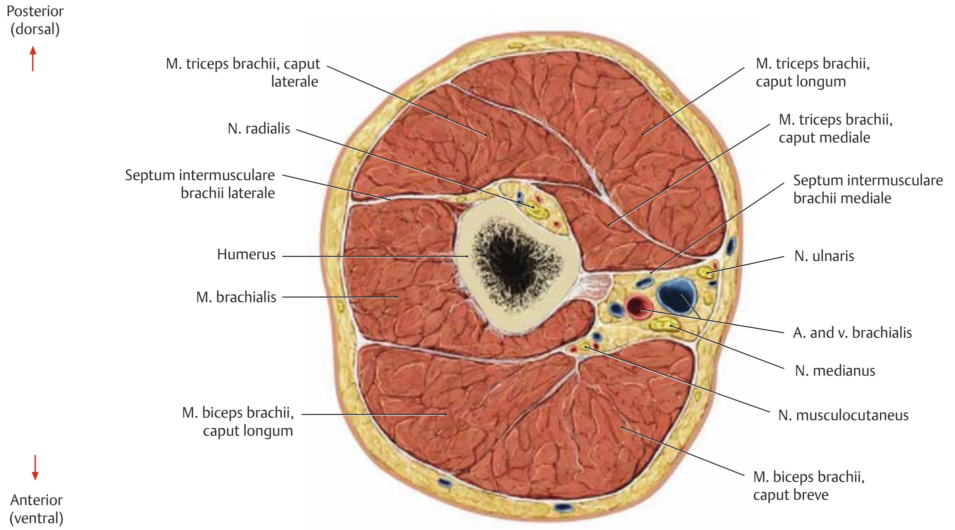


A Dissection of the arm.

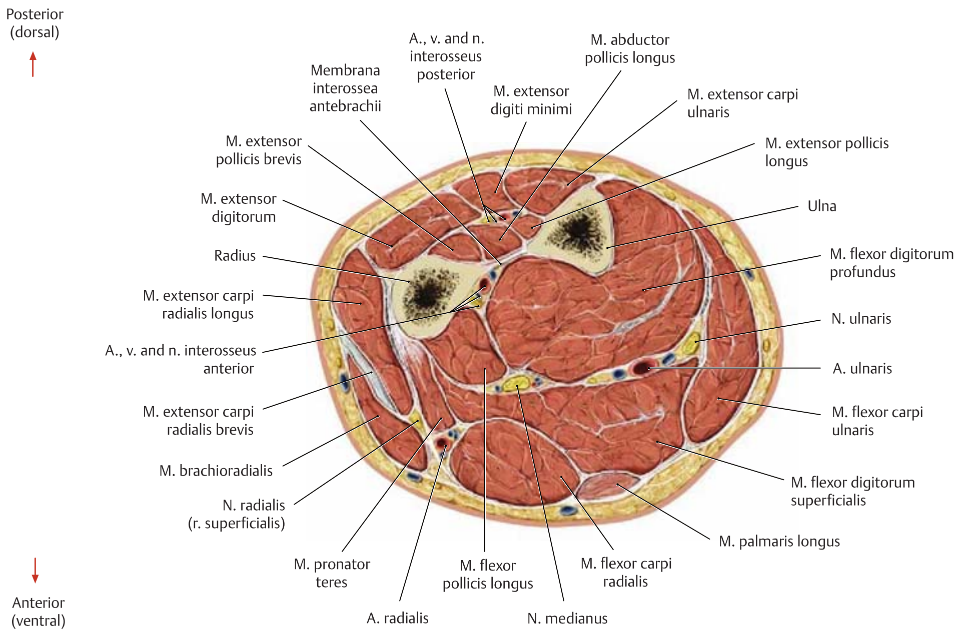


B Dissection of the forearm.

Fig. 22.50 **Transverse sections**
Right limb, proximal (superior) view.



A Arm (plane of section in Fig. 22.49A).

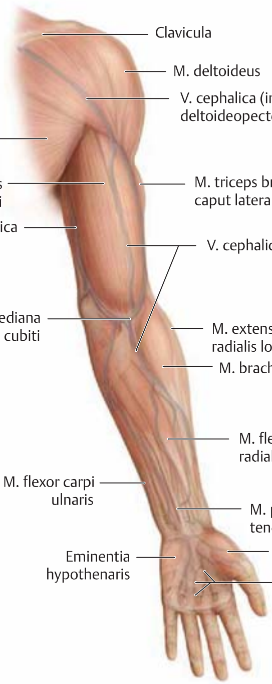


B Forearm (plane of section in Fig. 22.49B).

Surface Anatomy (I)

Fig. 23.1 **Upper limb: Anterior view**

A Surface anatomy, right limb.



B Musculature, left limb.

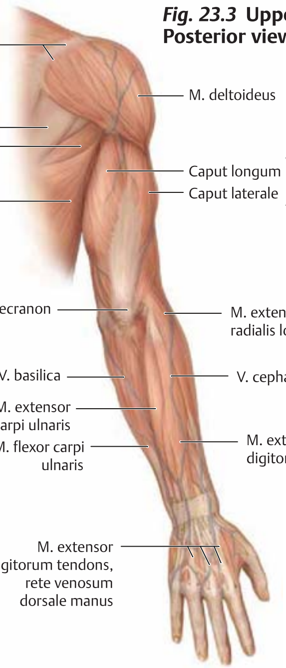
Fig. 23.2 **Palpable bony prominences**
Right limb.

A Anterior view.

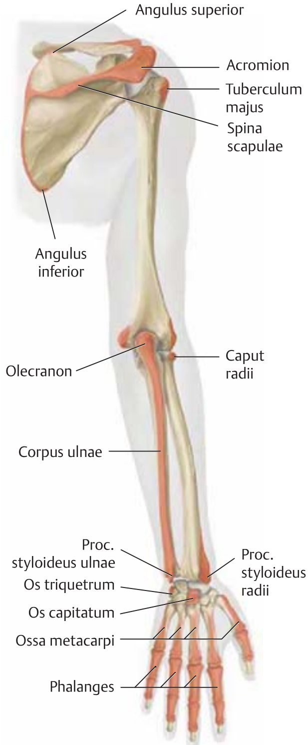
Q1: Which cutaneous nerves are most vulnerable during intravenous punctures (e.g., drawing blood, injections)?

Fig. 23.3 **Upper limb: Posterior view**

A Surface anatomy, left limb.



B Musculature, right limb.



B Posterior view.

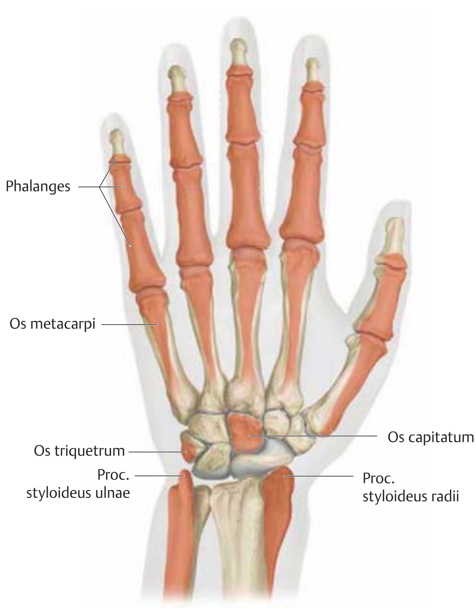
Q2: Palpation of which skeletal landmarks would allow you to locate and examine the collateral ligaments of the elbow?

See answers beginning on p. 626.

Surface Anatomy (II)

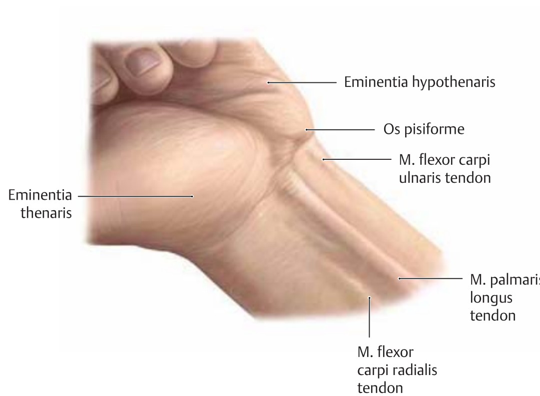
Fig. 23.4 **Palpable bony structures**
Left hand.

A Anterior (palmar) view.



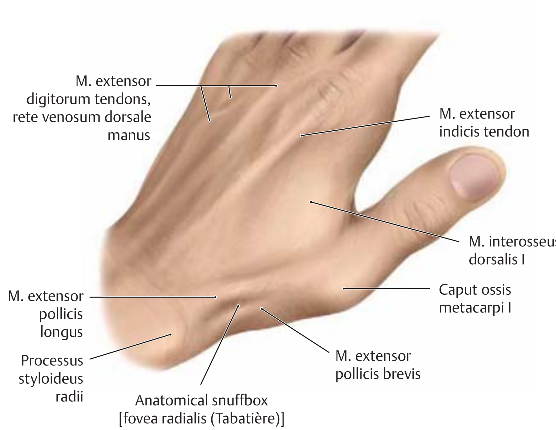
B Posterior (dorsal) view.

Fig. 23.5 **Surface anatomy of the wrist**
Left wrist, oblique anterolateral view.



Q3: How can the palpable tendons in the wrist be used to determine the location of key arteries and nerves?

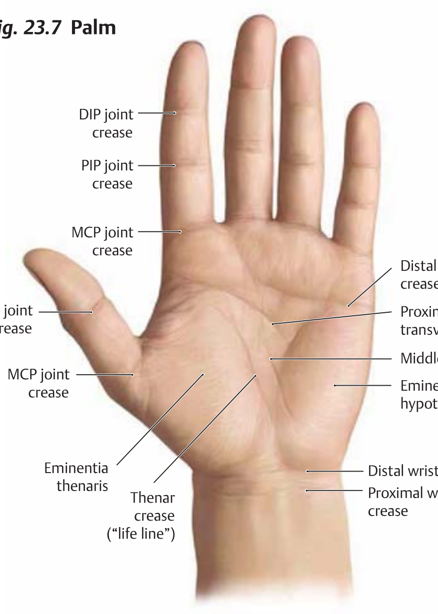
Fig. 23.6 **Anatomic snuffbox [fovea radialis (Tabatière)]**
Left hand, oblique posterolateral view.



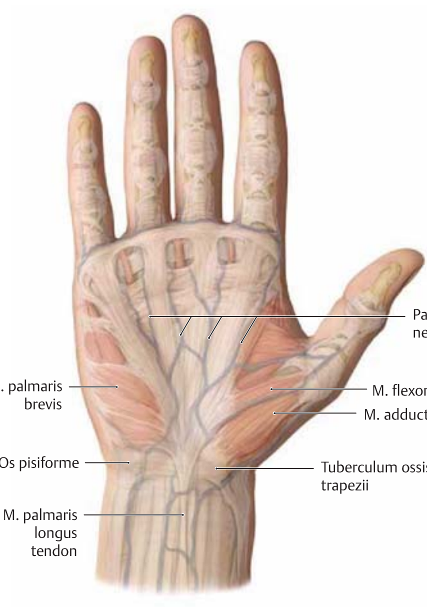
Q4: Tenderness in the base of the anatomic snuffbox can suggest a fracture of which of the carpal bones?

See answers beginning on p. 626.

Fig. 23.7 **Palm**

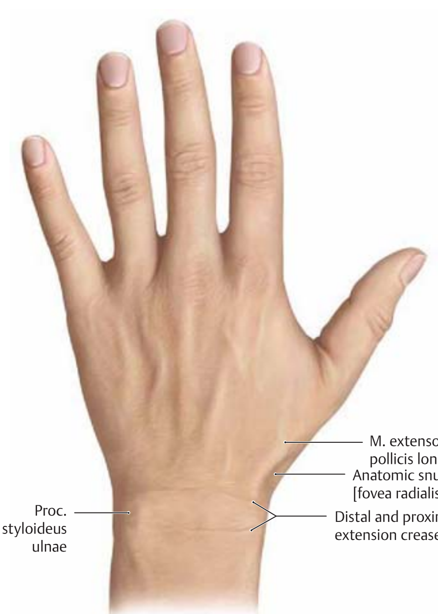


A Surface anatomy, left palm.

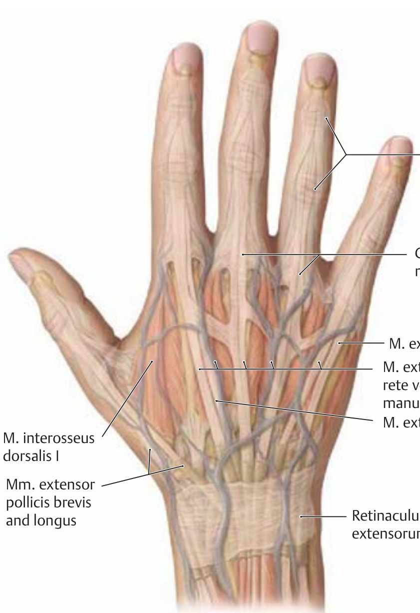


B Musculature, right palm.

Fig. 23.8 **Dorsum**



A Surface anatomy, left hand.



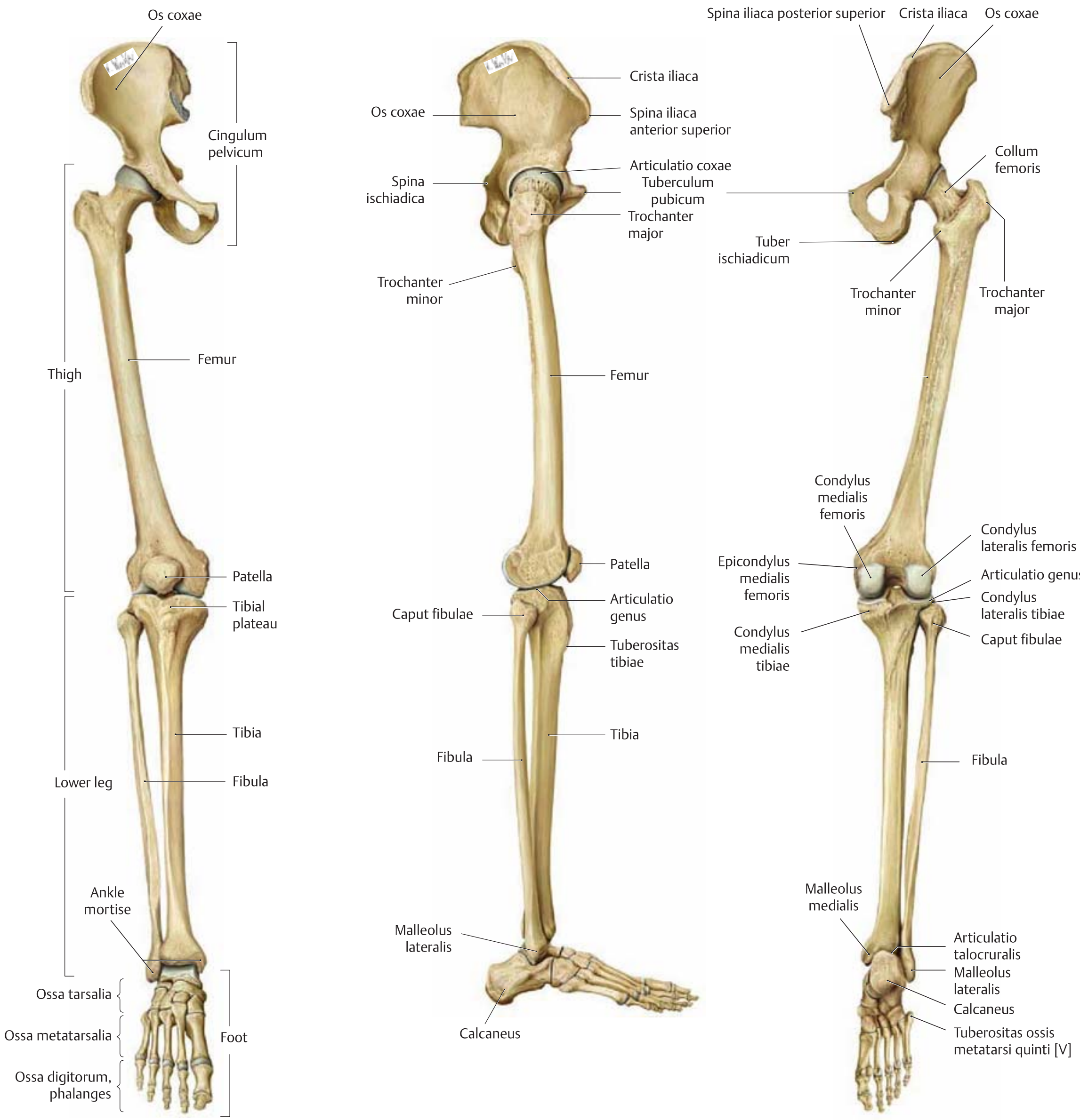
B Musculature, right hand.

Lower Limb

Bones of the Lower Limb

Fig. 24.1 Bones of the lower limb

Right limb. The skeleton of the lower limb consists of a pelvic girdle (cingulum pelvicum; os coxae and os sacrum) and an attached free limb. The free limb is divided into the thigh (femur), leg (tibia and fibula), and foot. It is connected to the pelvic girdle by the articulatio coxae.



A Anterior view.

B Right lateral view.

C Posterior view.

Fig. 24.2 **Line of gravity**
Right lateral view. The line of gravity runs vertically from the whole-body center of gravity to the ground with characteristic points of intersection.

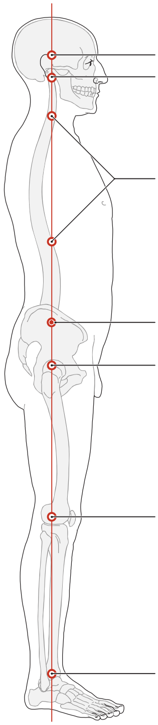
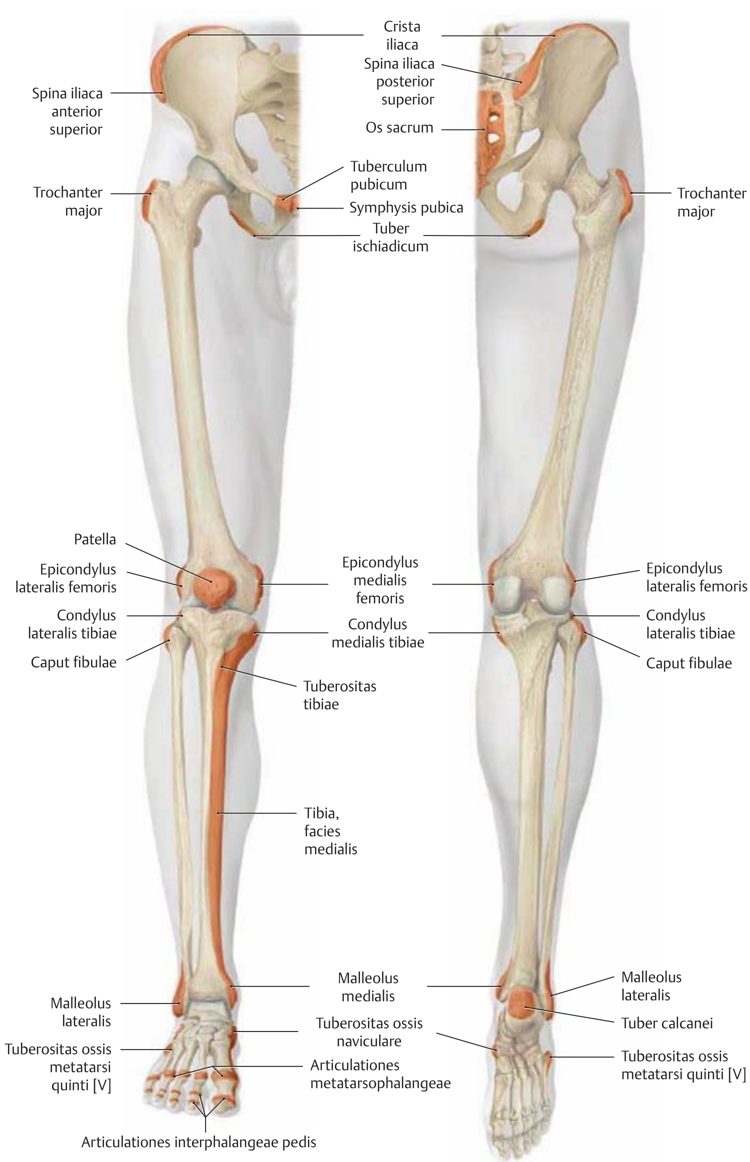


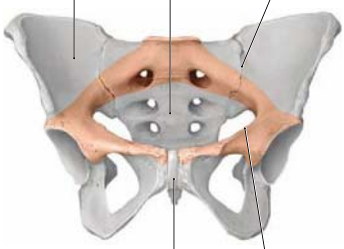
Fig. 24.3 **Palpable bony prominences in the lower limb**
Most skeletal elements of the lower limb have bony prominences, margins, or surfaces (e.g., medial or tibial surfaces) that can be palpated through the skin and soft tissues.



A Anterior view. **B** Posterior view.

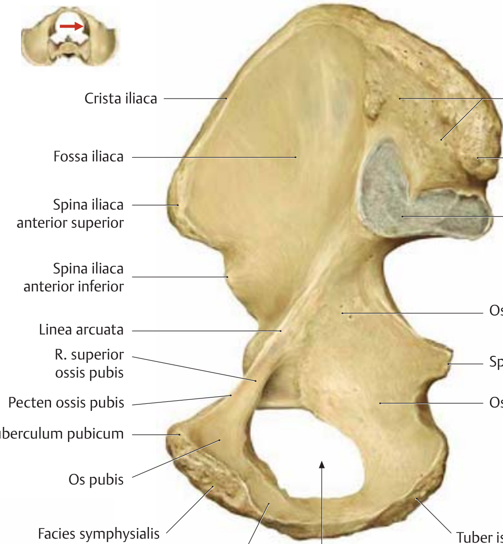
Pelvic Girdle & Os Coxae

Fig. 24.4 **Pelvic girdle**
Anterior view. Pelvic ring in red.

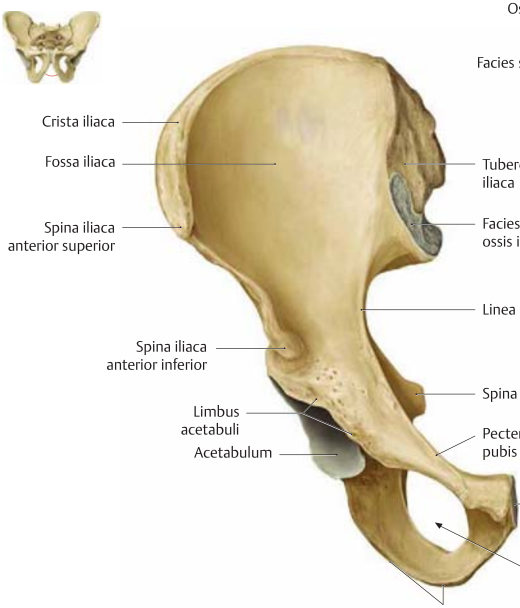


Each pelvic girdle consists of a hip bone (os coxae), which articulates with caput femoris. Unlike the shoulder girdle, the pelvic girdle is firmly integrated into the axial skeleton: the paired hip bones are connected to each other at the cartilaginous symphysis pubica and to os sacrum via the articulationes sacroiliacae. These attachments create the bony pelvic ring (red), permitting very little motion. This stability is an important prerequisite for the transfer of trunk loads to the lower limb (necessary for normal gait).

Fig. 24.5 **Right hip bone**



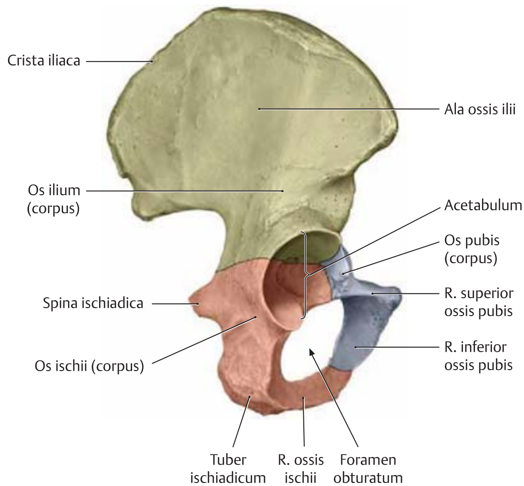
B Medial view.



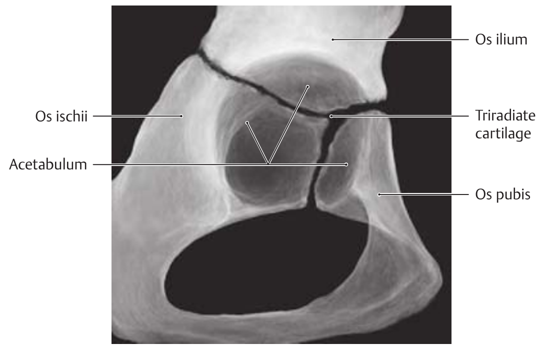
A Anterior view.

Fig. 24.6 Components of os coxae

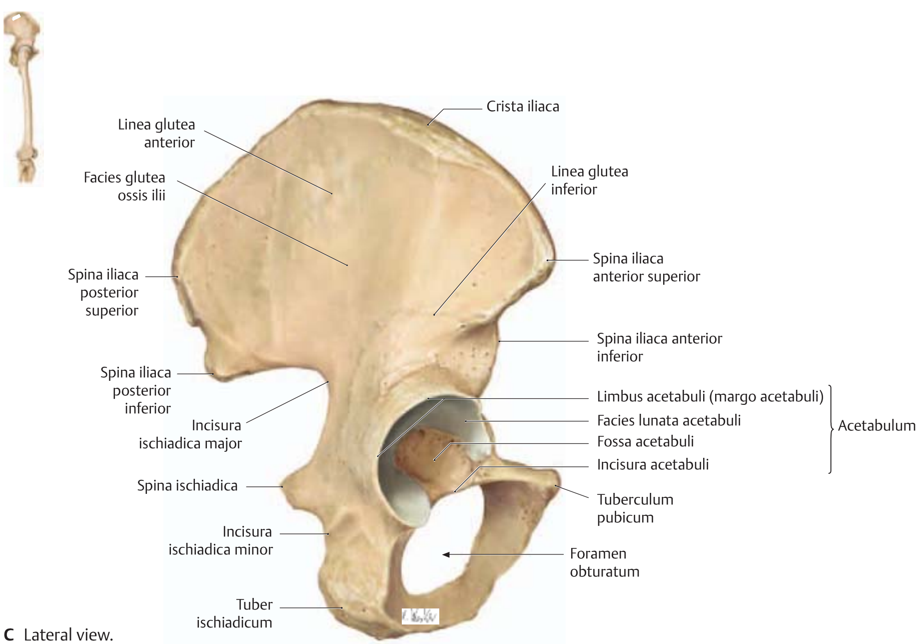
Right os coxae. The three bony elements of os coxae (os ilium, os ischium, and os pubis) come together at the acetabulum. Definitive fusion of the Y-shaped growth plate (triradiate cartilage) occurs between the 14th and 16th years of life.



A Triradiate cartilage of os coxae. Lateral view.



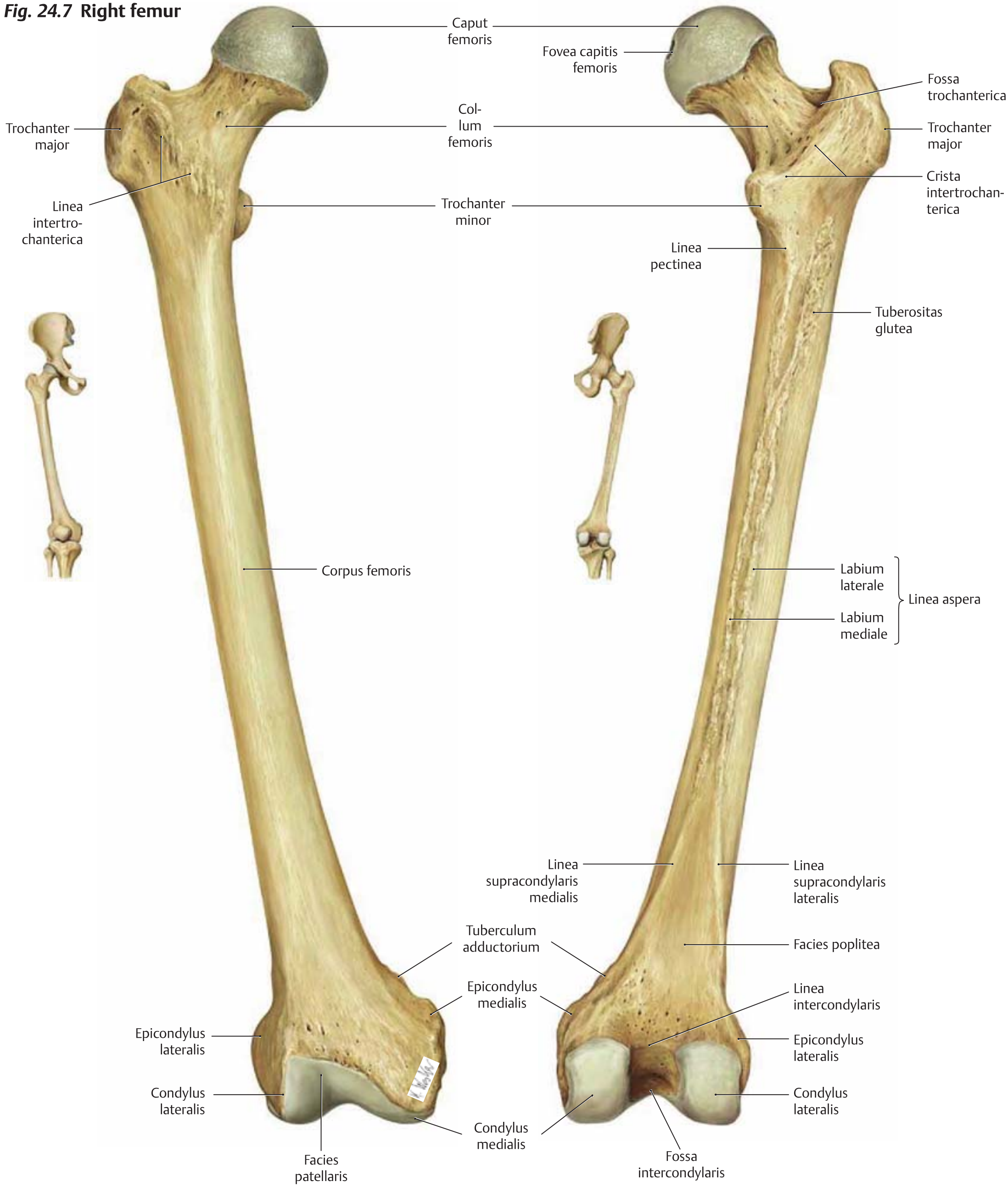
B Radiograph of right acetabulum of a child.



C Lateral view.

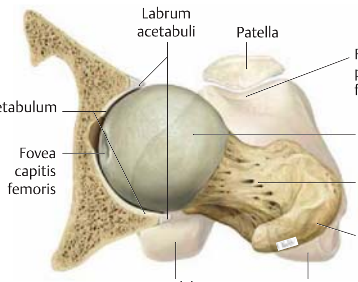
Femur

Fig. 24.7 **Right femur**



A Anterior view.

B Posterior view.

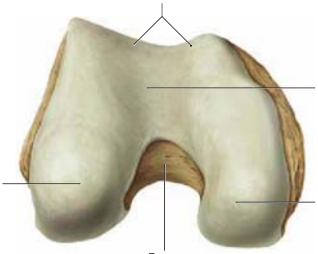


C Proximal view. The acetabulum has been sectioned in the horizontal plane.

Clinical

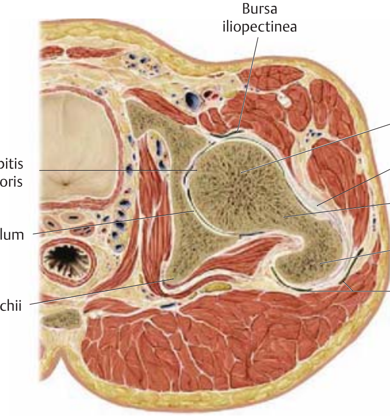
Fractures of femur

Femoral fractures caused by falls in patients with osteoporosis are most frequently located in collum femoris. Fractures of corpus femoris are less frequent and are usually caused by strong trauma (e.g., a car accident).

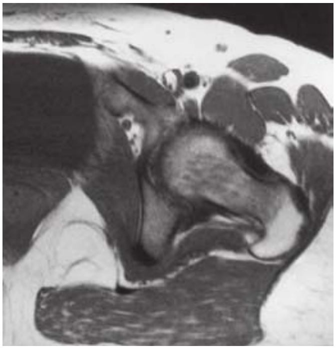


D Distal view. See pp. 382–383 for articulatio genus.

Fig. 24.8 **Caput femoris in articulatio coxae**
Right articulatio coxae, superior view.

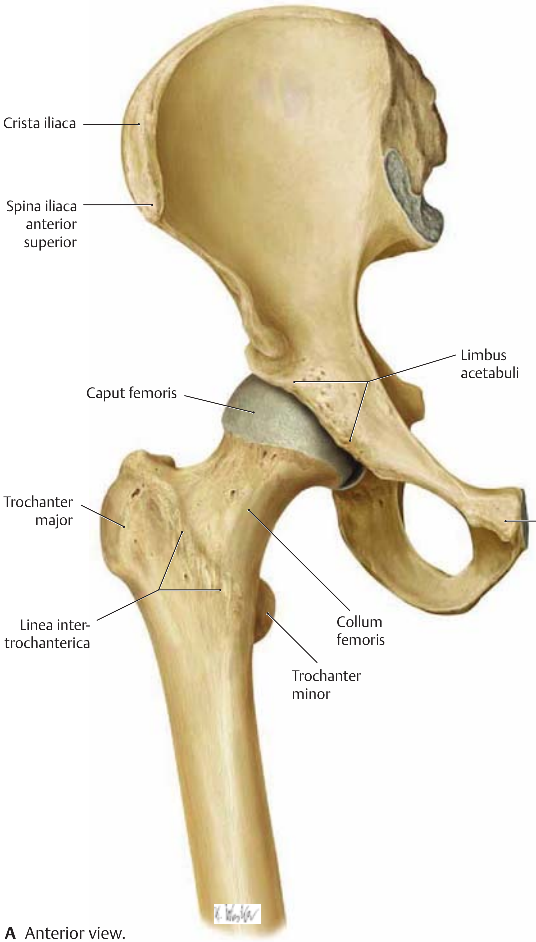


A Transverse section.



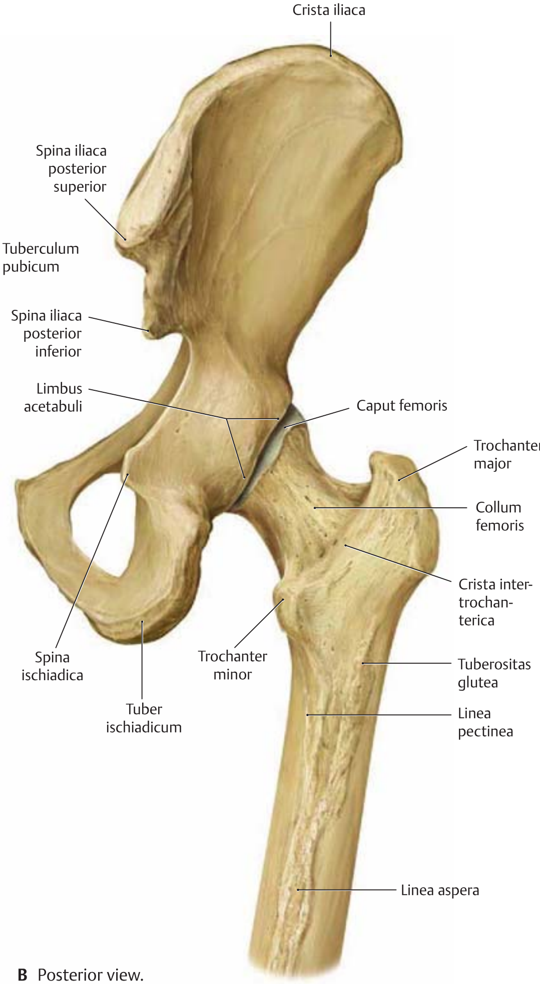
B T1-weighted MRI.

Articulatio coxae: Overview



A Anterior view.

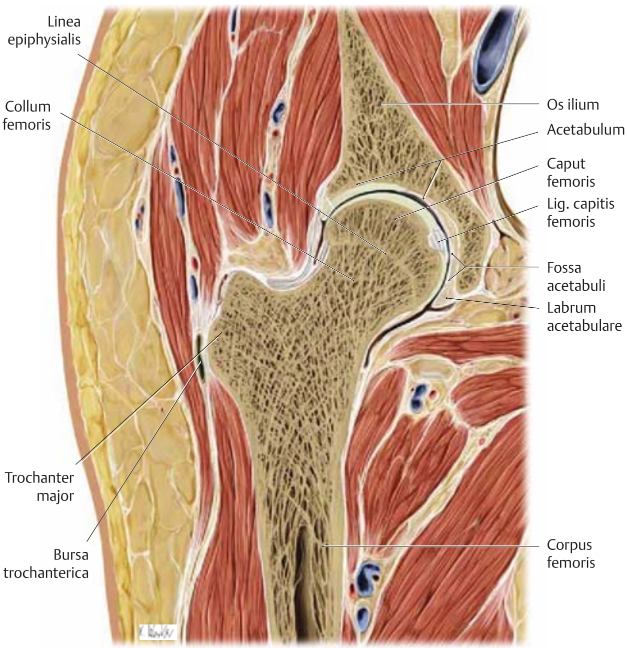
Fig. 24.9 **Right articulatio coxae**
Caput femoris articulates with the acetabulum of os coxae at the articulatio coxae, a special type of spheroidal (ball-and-socket) joint. The roughly spherical caput femoris (with an average radius of curvature of approximately 2.5 cm) is largely contained within the acetabulum.



B Posterior view.

Fig. 24.10 Articulatio coxae: Coronal section

Right articulatio coxae, anterior view.



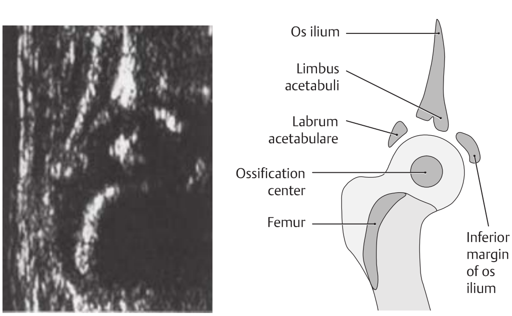
A Coronal section.

B T1-weighted MRI.

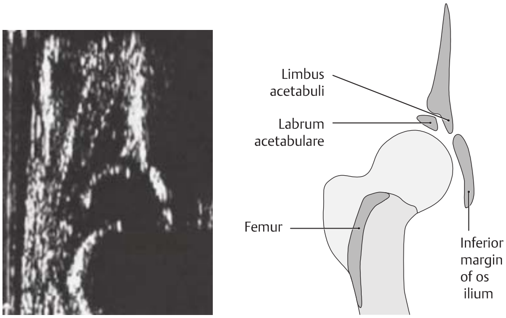
Clinical

Diagnosing hip dysplasia and dislocation

Ultrasonography, the most important imaging method for screening the infant hip, is used to identify morphological changes such as hip dysplasia and dislocation. Clinically, hip dislocation presents itself with instability and limited abduction of articulatio coxae, and leg shortening with asymmetry of the gluteal folds.



A Normal articulatio coxae in a 5-month-old.

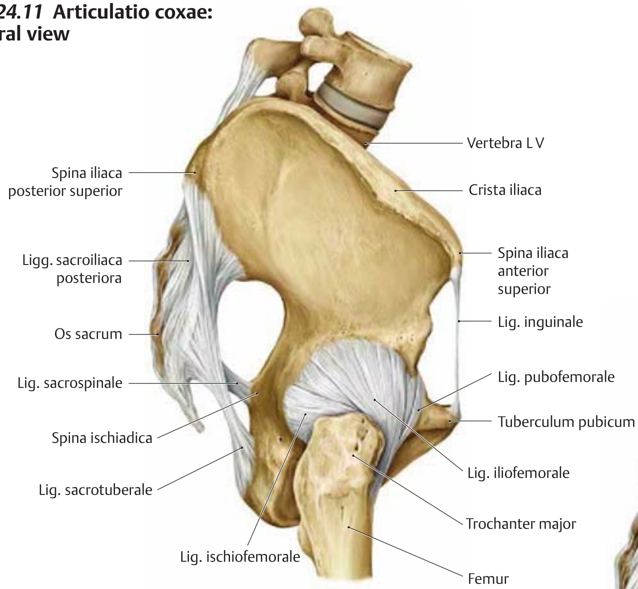


B Hip dislocation and dysplasia in a 3-month-old.

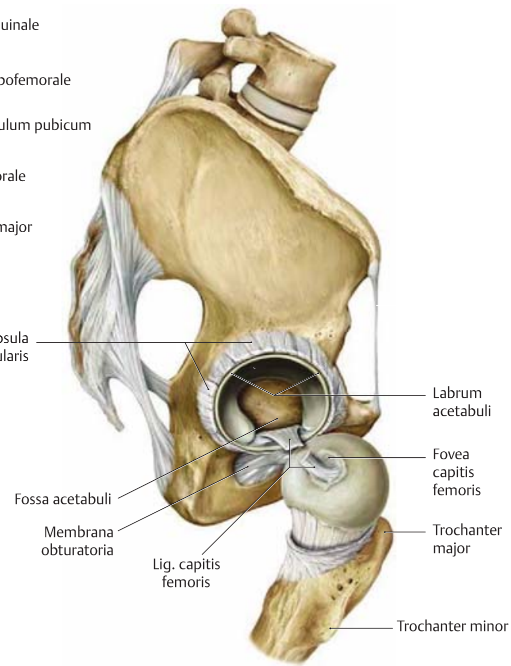
Articulatio Coxae: Ligaments & Capsule

The articulatio coxae has three major ligaments: lig. iliofemorale, lig. pubofemorale, and lig. ischiofemorale. The zona orbicularis (annular ligament) is not visible externally and encircles collum femoris like a buttonhole.

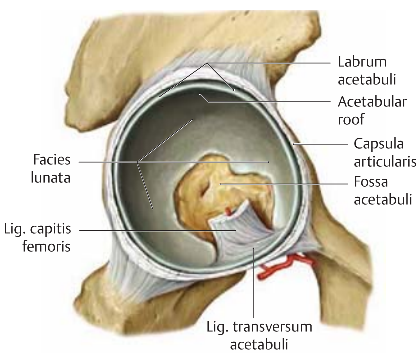
Fig. 24.11 Articulatio coxae: Lateral view



A Ligaments of articulatio coxae.

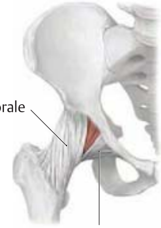


B Capsula articularis. The capsule has been divided and caput femoris dislocated to expose the cut lig. capitis femoris.

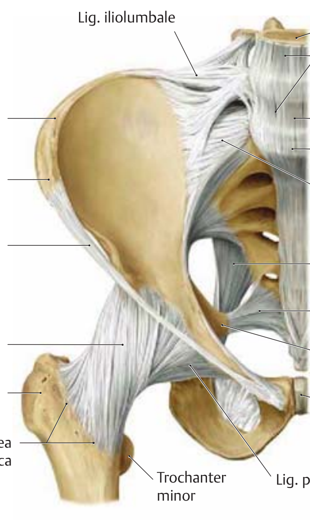


C Acetabulum of right articulatio coxae. *Note:* Lig. capitis femoris (cut) transmits branches from a. obturatoria that nourish the caput femoris (see p. 421).

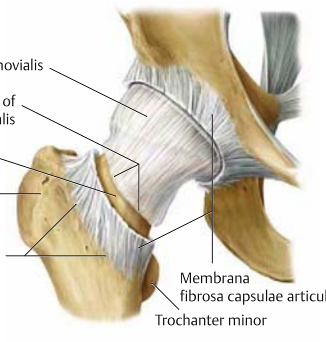
Fig. 24.12 Articulatio coxae: Anterior view



A Ligaments and weak spot (red).



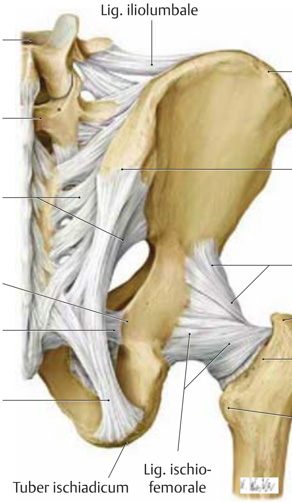
B Ligaments of articulatio coxae.



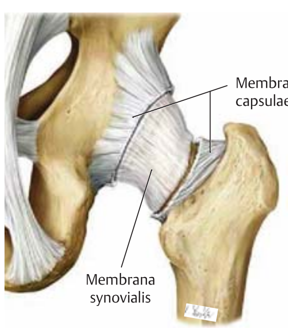
C Capsula articularis. *Removed:* Membrana fibrosa (at level of femoral neck).*Exposed:* Membrana synovialis.

Fig. 24.13 Articulatio coxae: Posterior view

A Ligaments and weak spot (red).



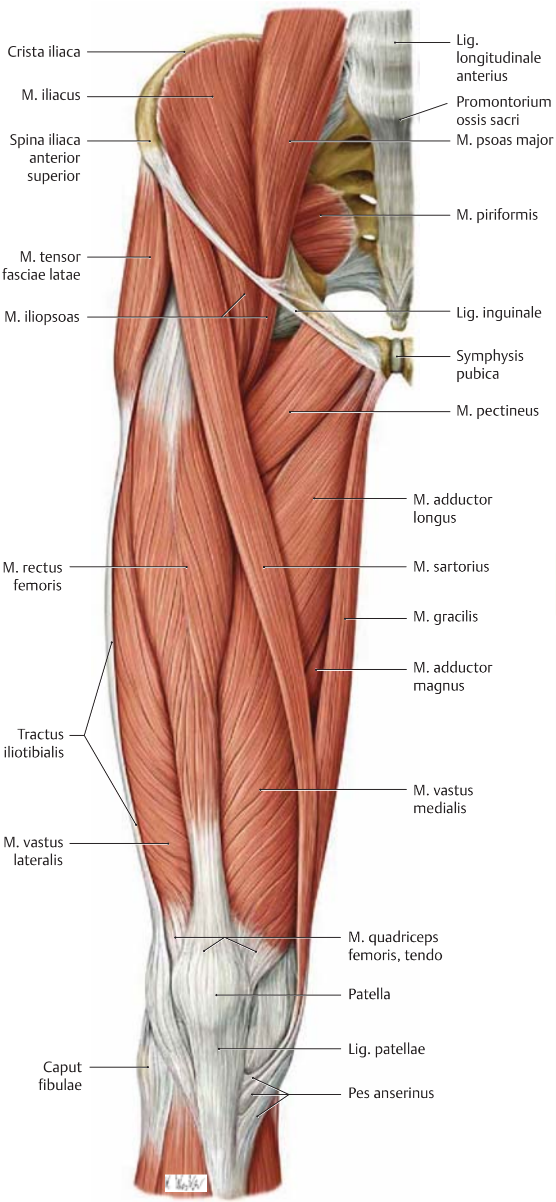
B Ligaments of the articulatio coxae.



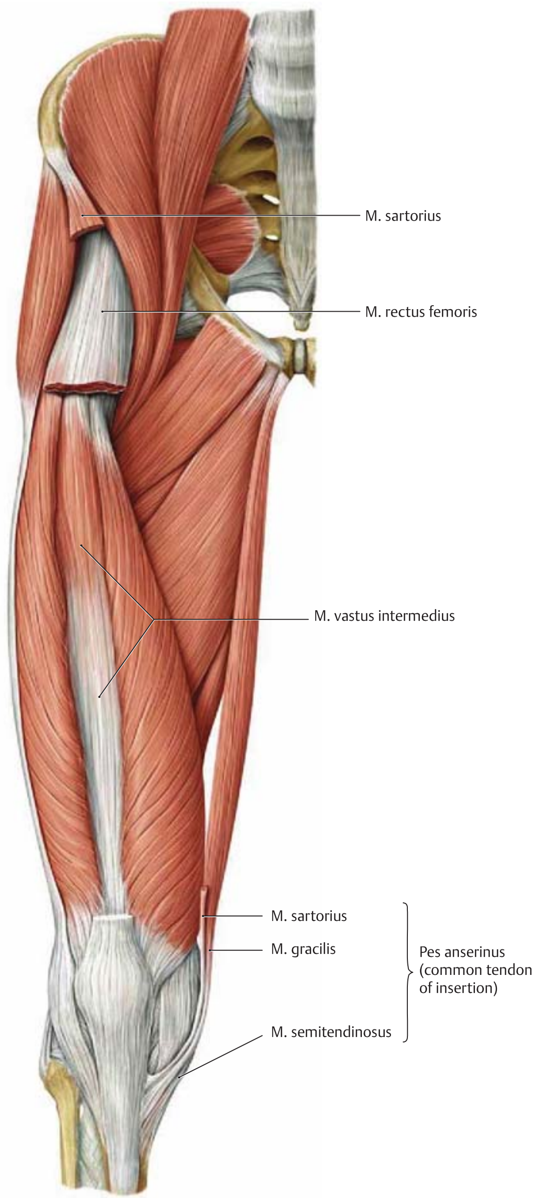
C Joint capsule.

Anterior Muscles of the Thigh, Hip & Regio Glutealis (I)

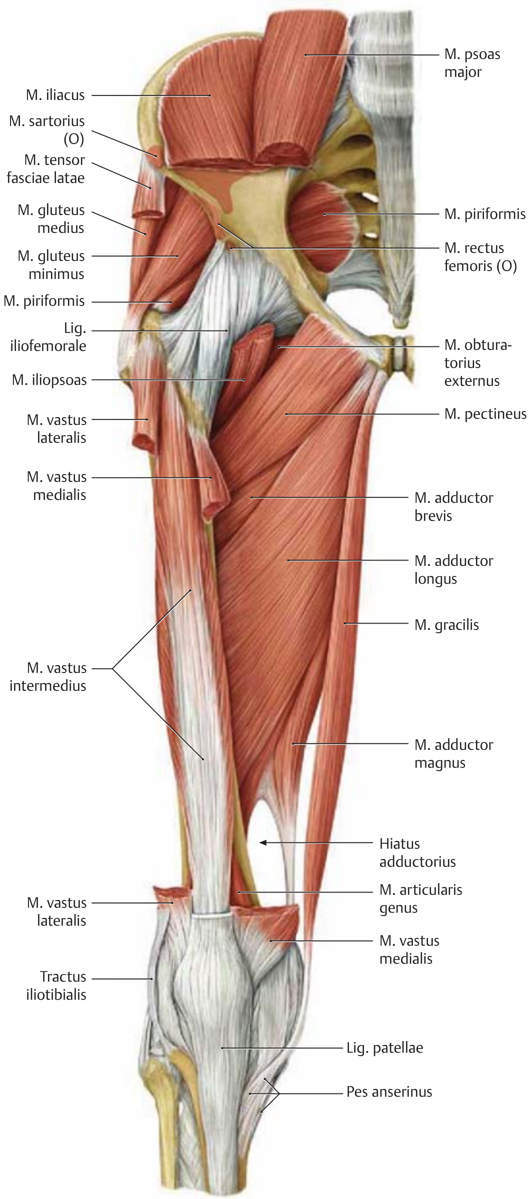
Fig. 24.14 **Muscles of the hip and thigh: Anterior view (I)**
Right limb. Muscle origins (O) are shown in red, insertions (I) in blue.



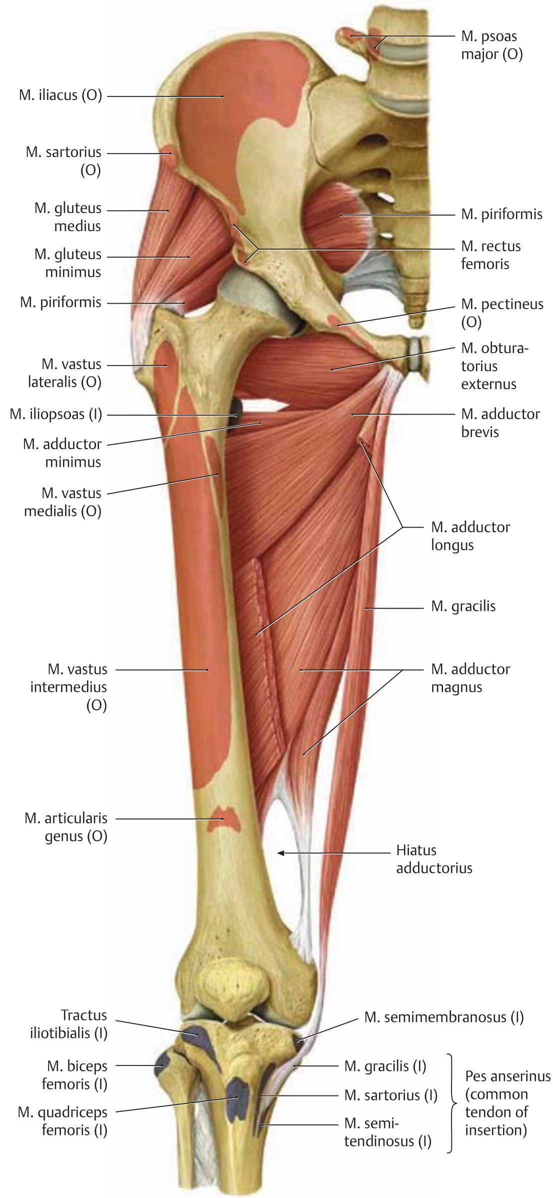
A *Removed:* Fascia lata (to the lateral tractus iliotibialis).



B *Removed:* M. sartorius and m. rectus femoris.



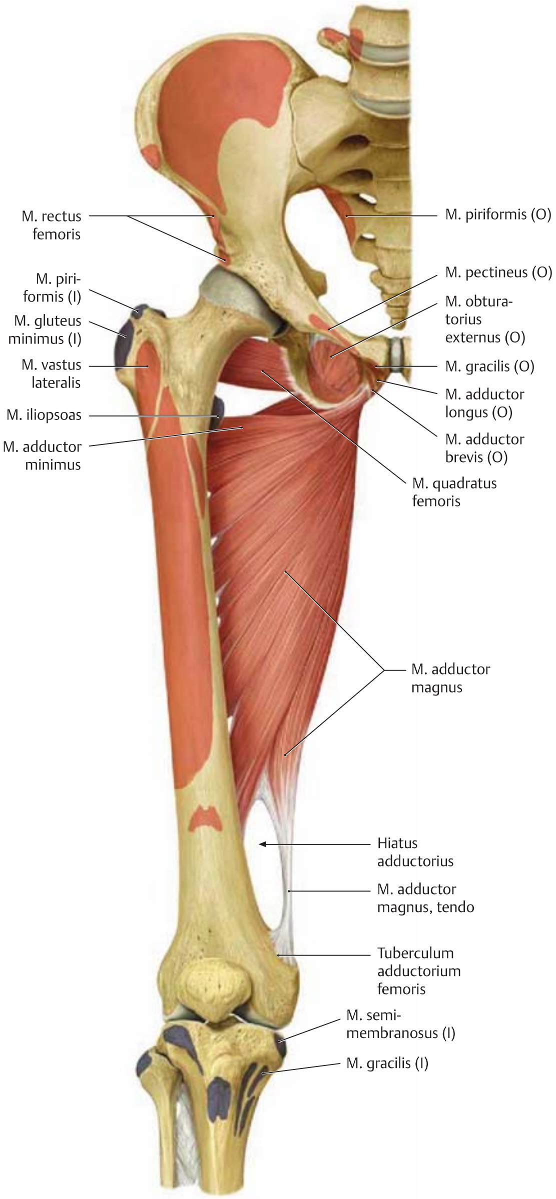
C *Removed:* M. rectus femoris (completely), m. vastus lateralis, m. vastus medialis, m. iliopsoas, and m. tensor fasciae latae.



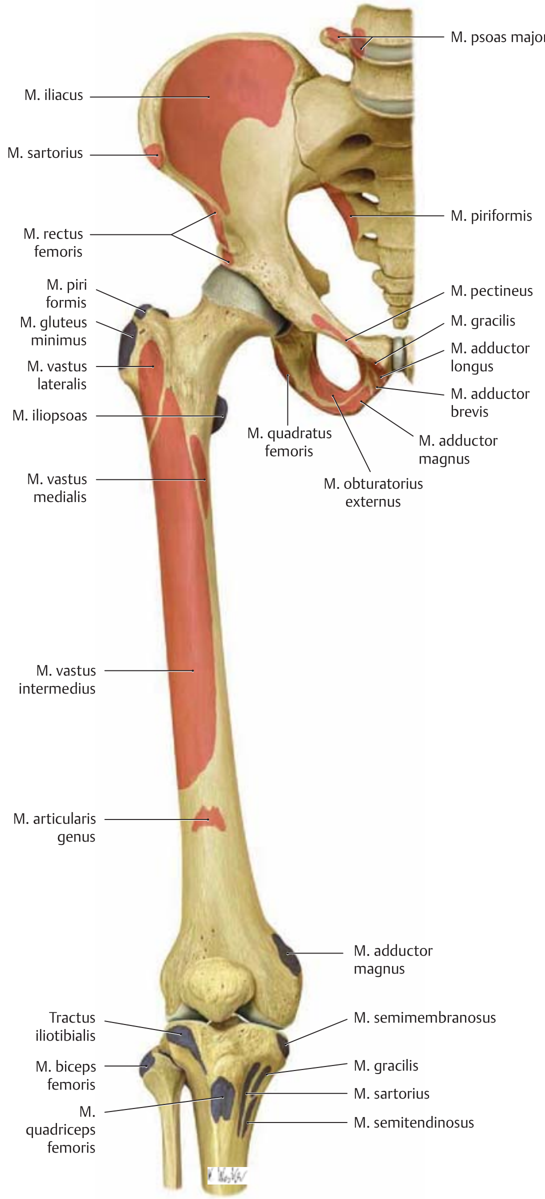
D *Removed:* M. quadriceps femoris (m. rectus femoris, m. vastus lateralis, m. vastus medialis, m. vastus intermedius), m. iliopsoas, m. tensor fasciae latae, m. pectineus, and midportion of m. adductor longus.

Anterior Muscles of the Thigh, Hip & Regio Glutealis (II)

Fig. 24.15 **Muscles of the hip and thigh: Anterior view (II)**
Right limb. Muscle origins (O) are shown in red, insertions (I) in blue.

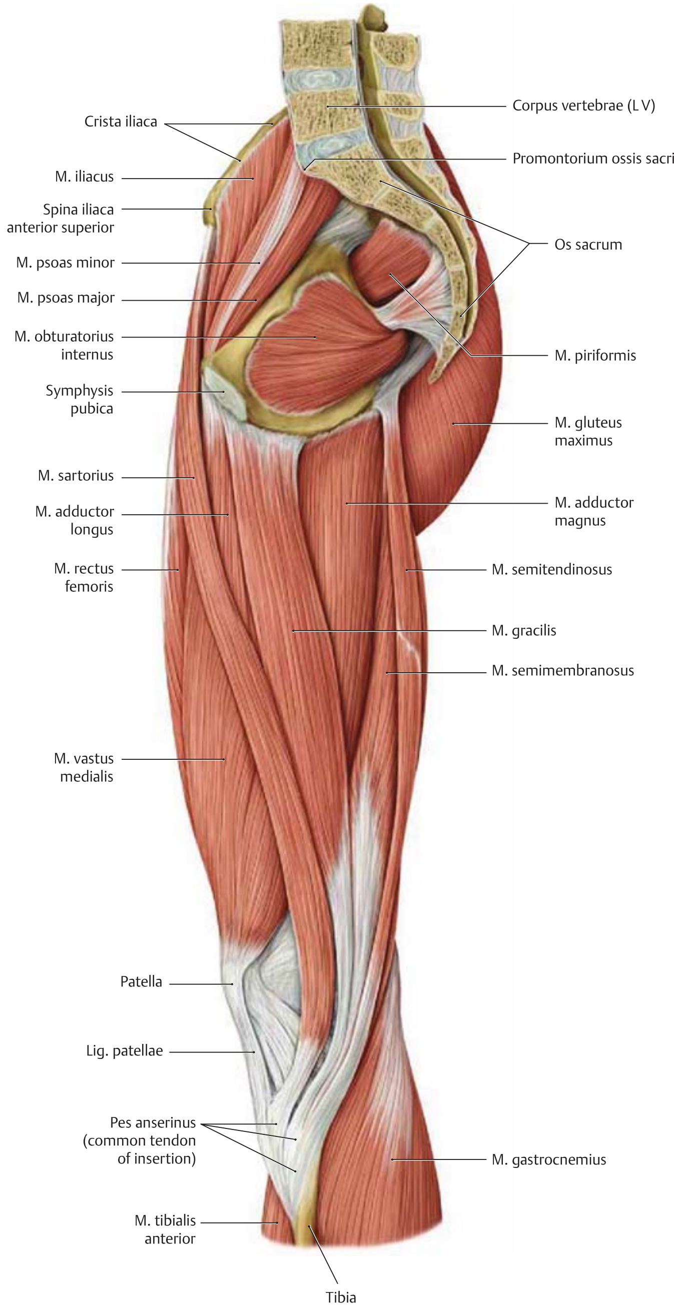


A *Removed:* M. gluteus medius and minimus, m. piriformis, m. obturatorius externus, m. adductor brevis and longus, and m. gracilis.



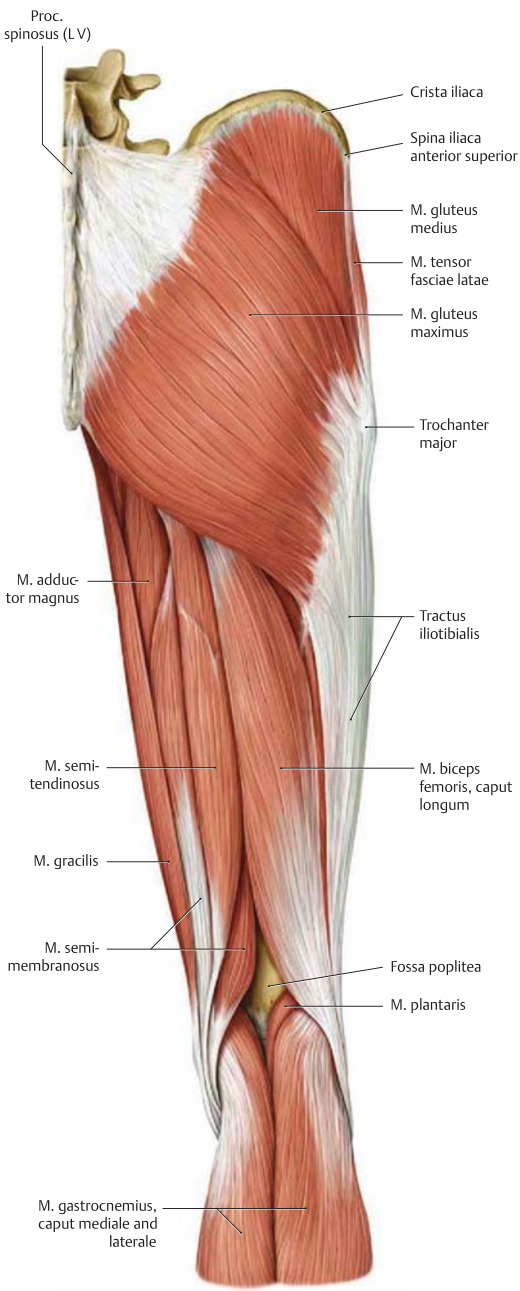
B *Removed:* All muscles.

Fig. 24.16 **Muscles of the hip, thigh, and regio glutealis: Medial view**
Midsagittal section.

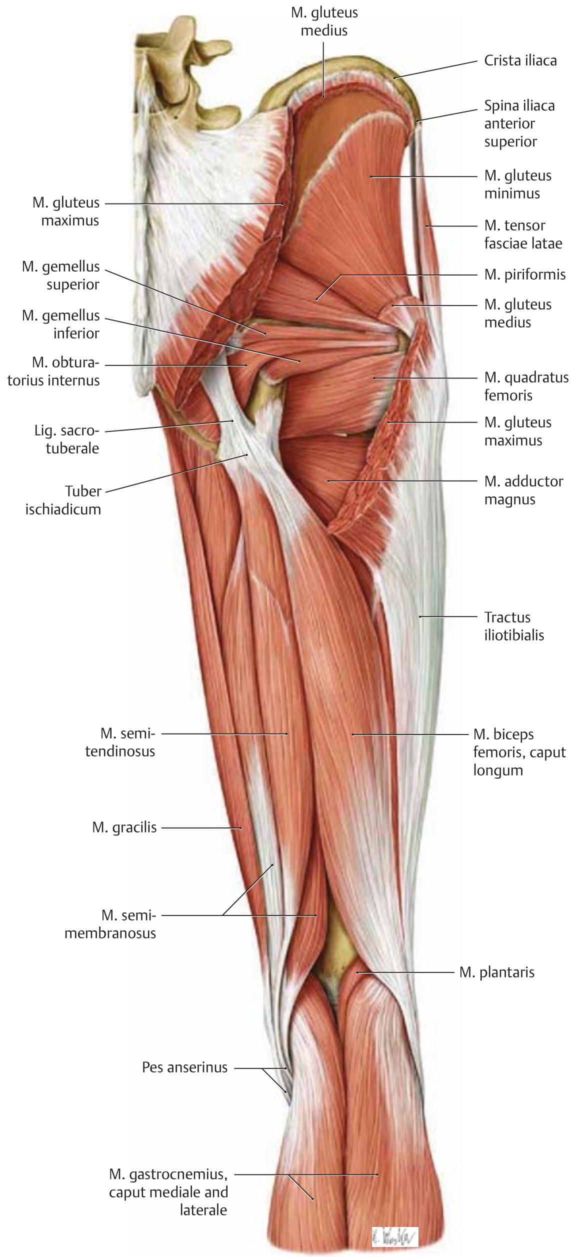


Posterior Muscles of the Thigh, Hip & Regio Glutealis (I)

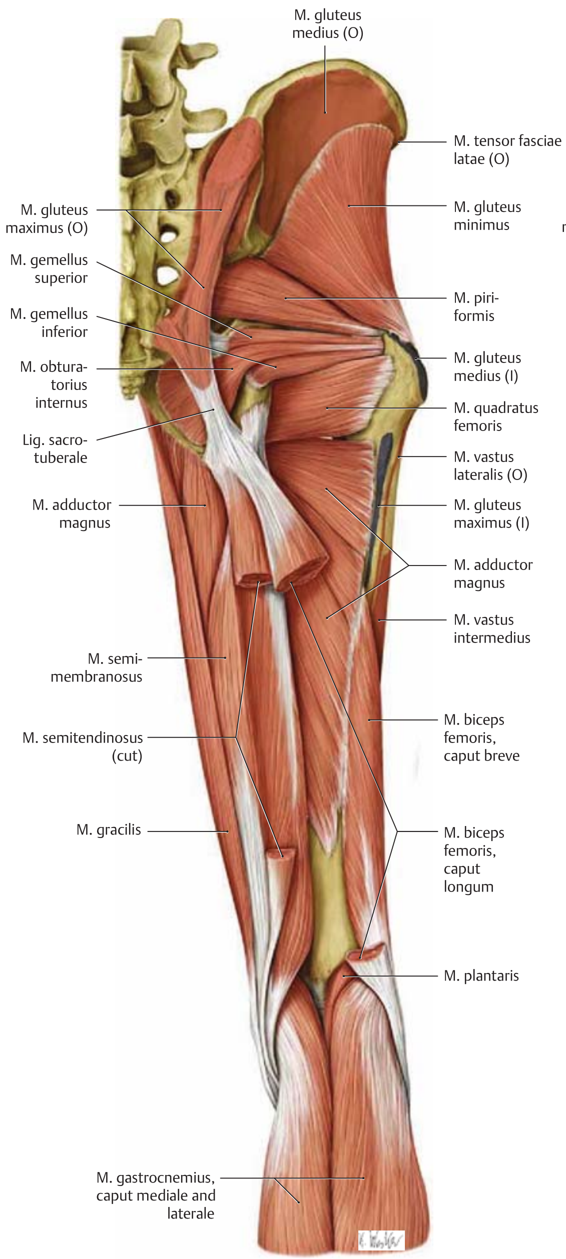
Fig. 24.17 **Muscles of the hip, thigh, and regio glutealis: Posterior view (I)**
Right limb. Muscle origins (O) are shown in red, insertions (I) in blue.



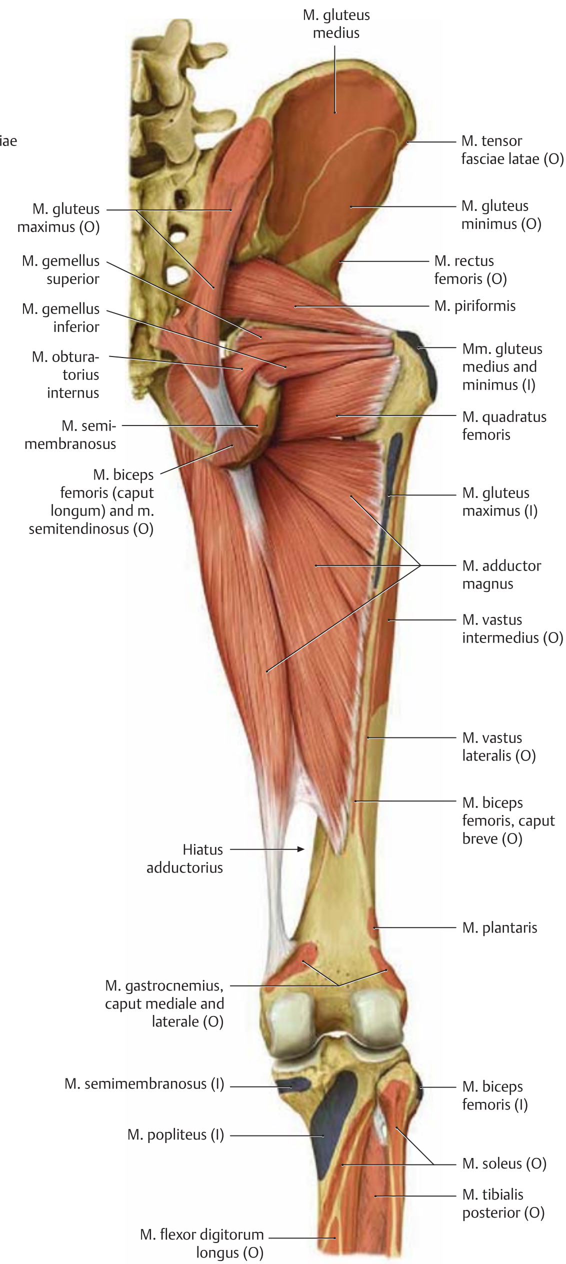
A *Removed:* Fascia lata (to tractus iliotibialis).



B *Partially removed:* Mm. gluteus maximus and medius.



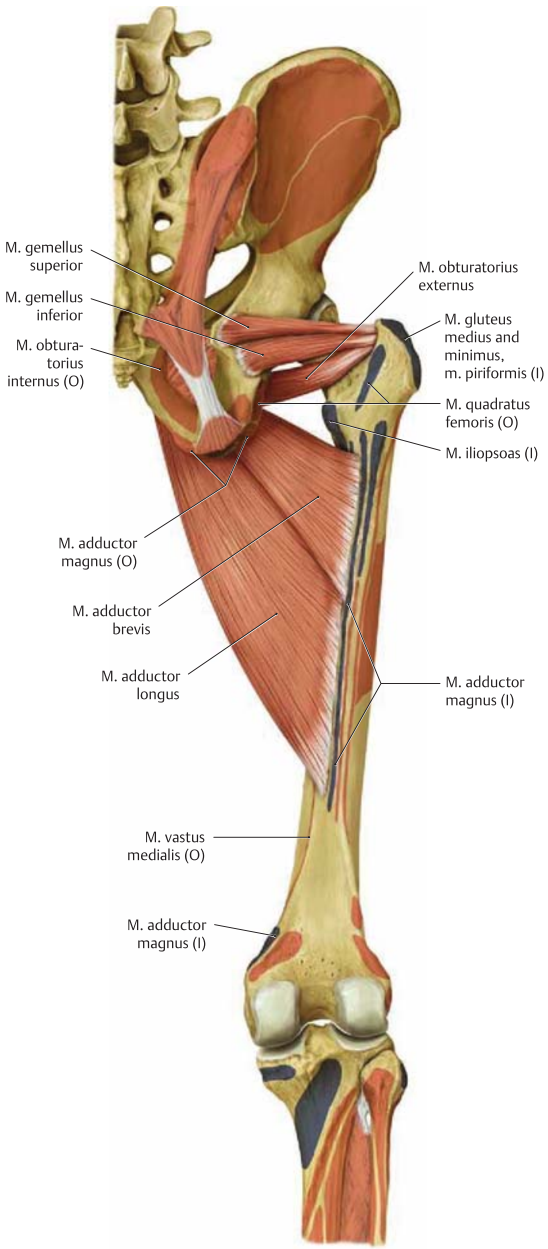
C *Removed:* M. semitendinosus and m. biceps femoris (partially); m. gluteus maximus and medius (completely).



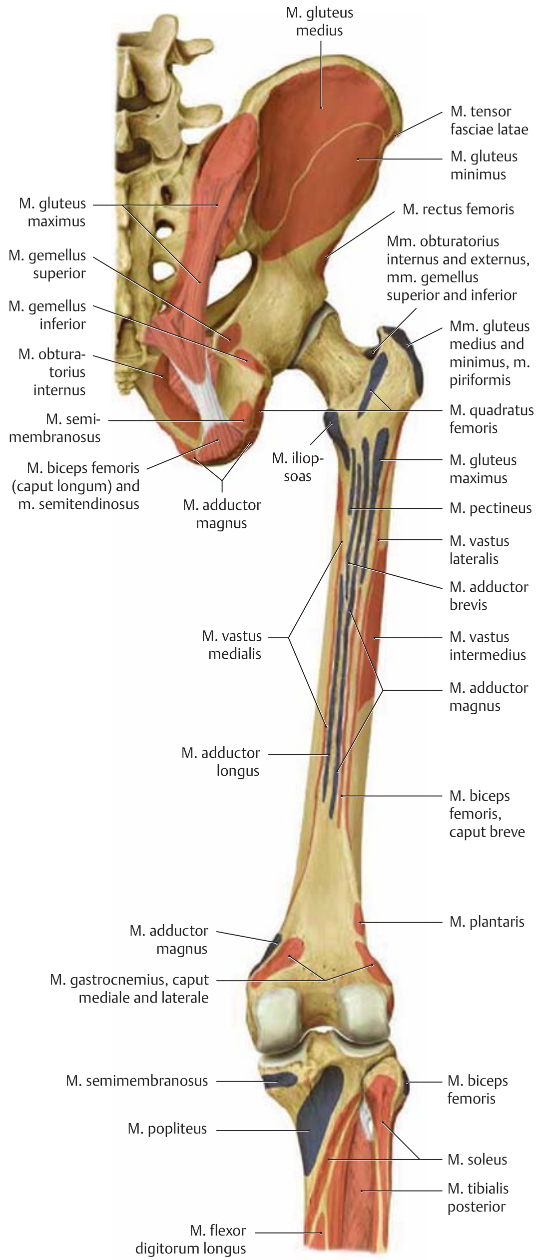
D *Removed:* Hamstrings (m. semitendinosus, m. semimembranosus, and m. biceps femoris), m. gluteus minimus, m. gastrocnemius, and

Posterior Muscles of the Thigh, Hip & Regio Glutealis (II)

Fig. 24.18 **Muscles of the hip, thigh, andregio glutealis: Posterior view (II)**
Right limb. Muscle origins (O) are shown in red, insertions (I) in blue.

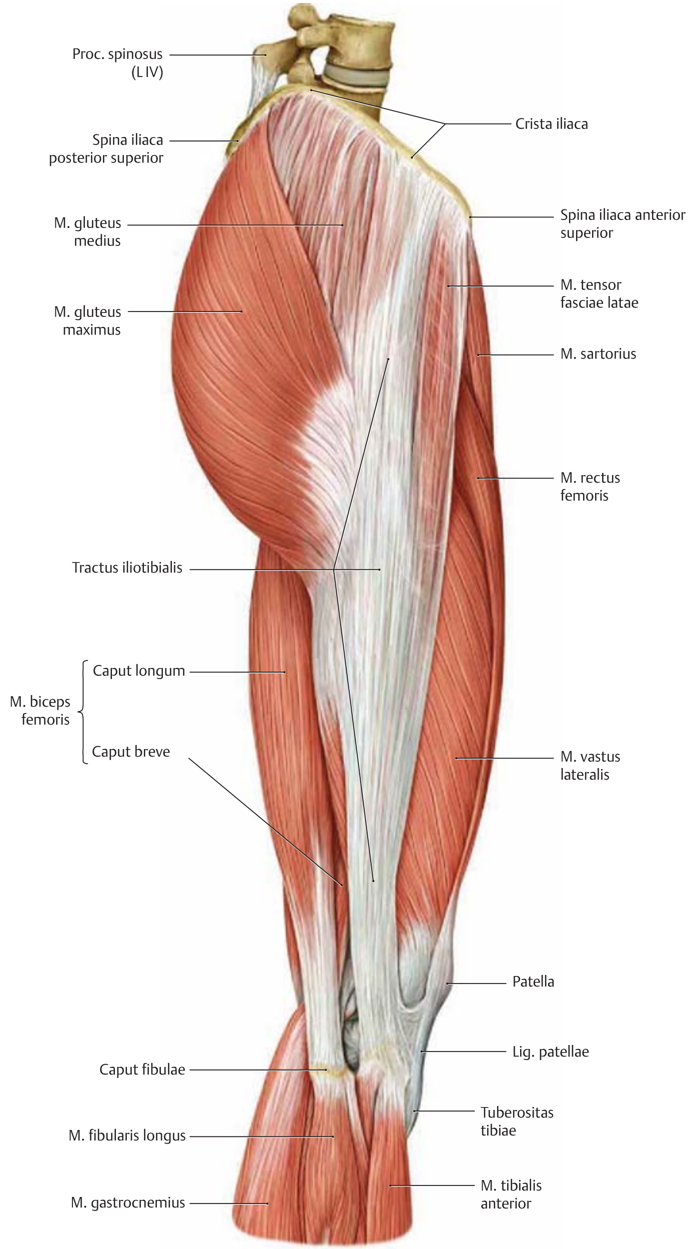


A *Removed:* M. piriformis, m. obturatorius internus, m. quadratus femoris, and m. adductor magnus.



B *Removed:* All muscles.

Fig. 24.19 **Muscles of the hip, thigh, and gluteal region: Lateral view**
Note: Tractus iliotibialis (the thickened band of fascia lata) functions as a tension band to reduce the bending loads on the proximal femur.

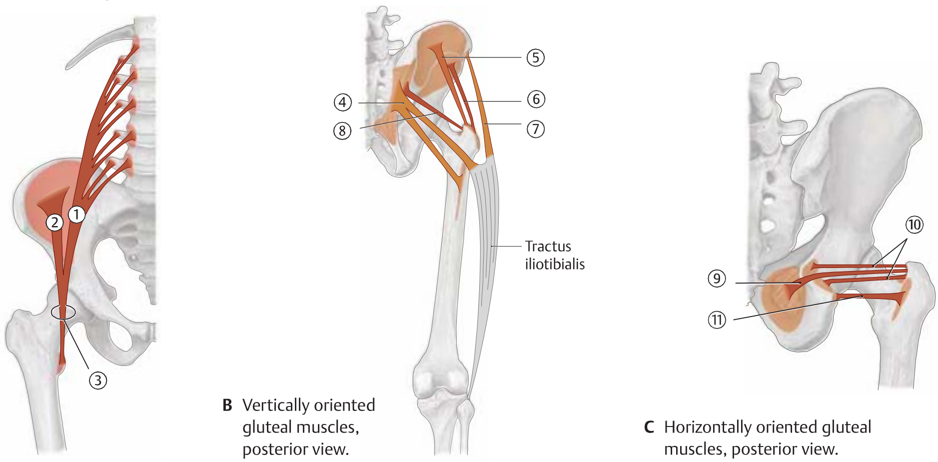


Muscle Facts (I)

Table 24.1 Psoas and iliacus muscles

Muscles		Origin	Insertion	Innervation	Action
③ Mm. iliopsoas	M. psoas minor	Vertebrae T XII–L I (Disci intervertebrales) (lateral surfaces)	Arcus iliopectineus	Direct branches from the lumbar plexus (psoas) (L2–L4)	Assists in upward rotation of the pelvis
	① M. psoas major	*Superficial:* Vertebrae T XII–L IV (Disci intervertebrales) (lateral surfaces) *Deep:* Vertebrae L I–L V (proc. transversus)	Trochanter minor		• Articulatio coxae: flexion and external rotation • Lumbar spine: *unilateral* contraction (with the femur fixed) bends the trunk laterally to the same side; *bilateral* contraction raises the trunk from the supine position
	② M. iliacus	Fossa iliaca		N. femoralis (L2–L4)	

Fig. 24.20 **Muscles of the hip**
Right side.



A M. iliopsoas, anterior view.

B Vertically oriented gluteal muscles, posterior view.

C Horizontally oriented gluteal muscles, posterior view.

Table 24.2 Gluteal muscles

Muscle	Origin	Insertion	Innervation	Action
④ M. gluteus maximus	Os sacrum (fascies posterior), os ilium (gluteal surface, pars posterior), fascia thoracolumbalis, lig. sacrotuberale	• Fibrae superior: tractus iliotibialis • Fibrae inferior: tuberositas glutea	N. gluteus inferios (L5–S2)	• Entire muscle: extends and externally rotates the hip in sagittal and coronal planes • Upper fibers: abduction • Lower fibers: adduction
⑤ M. gluteus medius	Os ilium (gluteal surface below the iliac crest between lineae gluteae anterior and posterior)	Trochanter major (lateral surface)	N. gluteus superior (L4–S1)	• Entire muscle: abducts the hip, stabilizes the pelvis in the coronal plane • Anterior part: flexion and internal rotation • Posterior part: extension and external rotation
⑥ M. gluteus minimus	Os ilium (gluteal surface below the origin m. gluteus medius)	Trochanter major (anterolateral surface)		
⑦ M. tensor fasciae latae	Spina iliaca anterior superior	Tractus iliotibialis		• Tenses the fascia lata • Articulatio coxae: abduction, flexion, and internal rotation
⑧ M. piriformis	Facies pelvica of os sacrum	Apex of the trochanter major	Direct branches from the plexus sacralis (S1–S2)	• External rotation, abduction, and extension of articulatio coxae • Stabilizes articulatio coxae
⑨ M. obturatorius internus	Inner surface of membrana obturatoria and its bony boundaries	Fossa trochanterica	Direct branches from the plexus sacralis (L5, S1)	External rotation, adduction, and extension of articulatio coxae (also active in abduction, depending on the joint's position)
⑩ Mm. gemelli	• M. gemellus superior: spina ischiadica • M. gemellus inferior: tuber ischiadicum	Fossa trochanterica		
⑪ M. quadratus femoris	Lateral border of the tuber ischiadicum	Crista intertrochanterica		External rotation and adduction of articulatio coxae

Fig. 24.21 **Mm. psoas and m. iliacus**
Right side, anterior view.

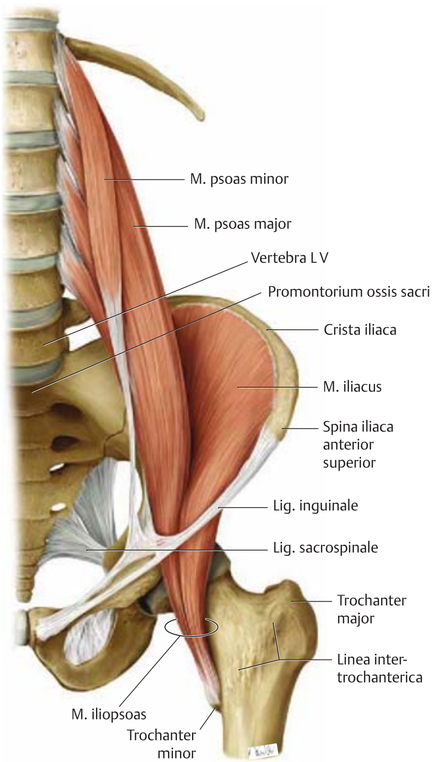


Fig. 24.22 **Superficial muscles of the gluteal region**
Right side, posterior view.

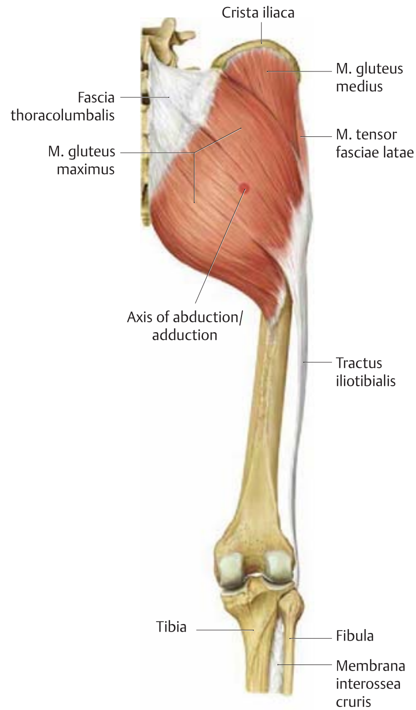
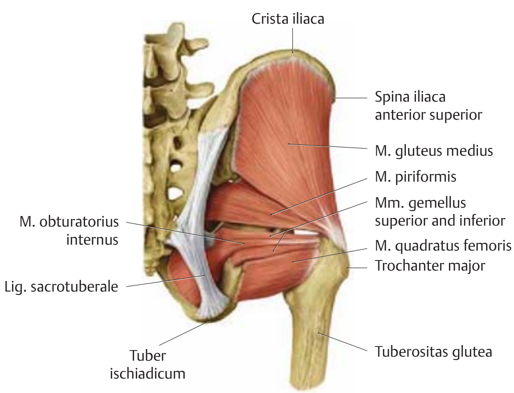
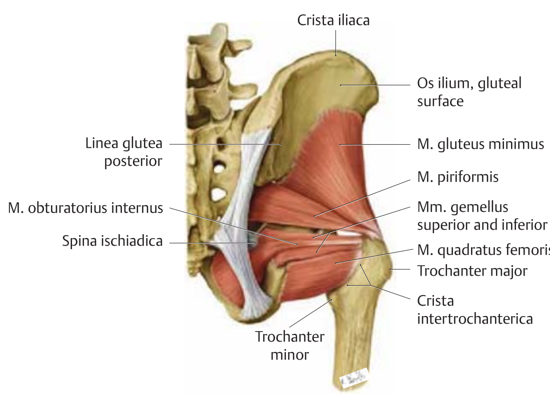


Fig. 24.23 **Deep muscles of the gluteal region**



A Deep layer with m. gluteus maximus removed.

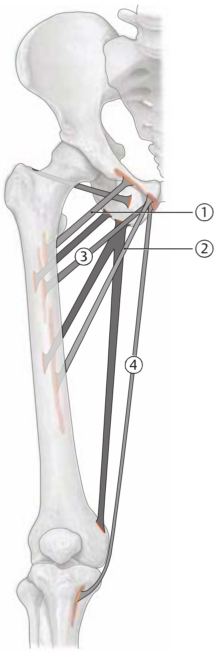


B Deep layer with m. gluteus medius removed.

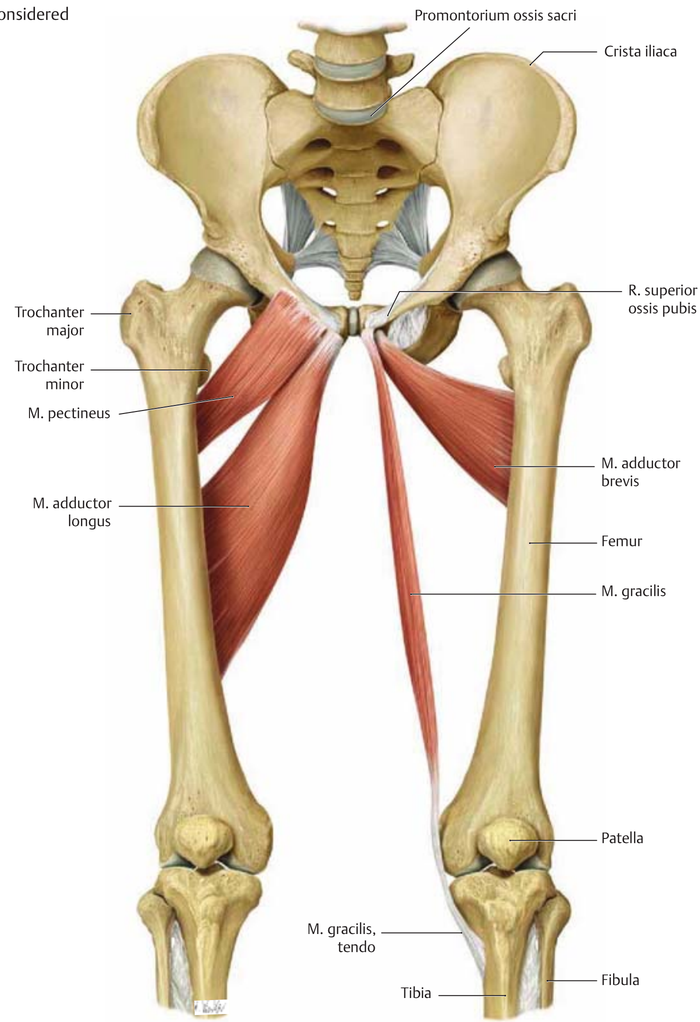
Muscle Facts (II)

Functionally, the medial thigh muscles are considered the adductors of the hip.

Fig. 24.24 ***Medial group: Superficial layer***
Right side, anterior view.



A Schematic.

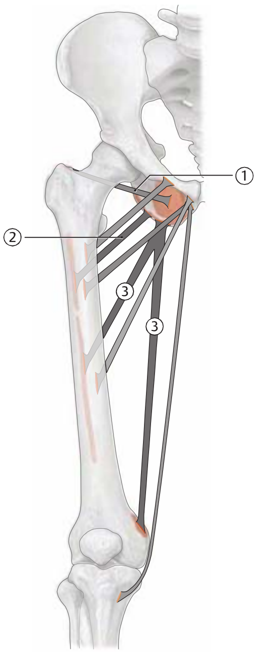


B Superficial adductor group.

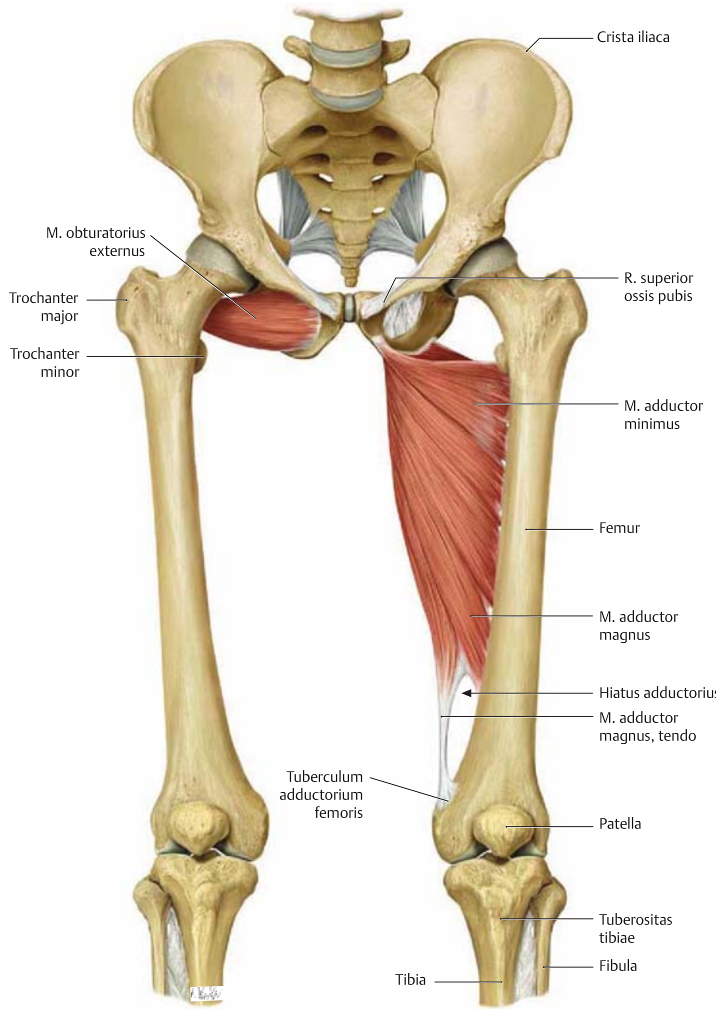
Table 24.3 **Medial thigh muscles: Superficial layer**

Muscle	Origin	Insertion	Innervation	Action
① M. pectineus	Pecten ossis pubis	Linea pectinea	N. femoralis, N. obturatorius (L2, L3)	• Articulatio coxae: adduction, external rotation, and slight flexion • Stabilizes the pelvis in the coronal and sagittal planes
② M. adductor longus	Os pubis (superior pubic ramus and anterior side of the symphysis)	Femur (labium mediale linea aspera)	N. obturatorius (L2–L4)	• Articulatio coxae: adduction and flexion (up to 70 degrees); extension (past 80 degrees of flexion) • Stabilizes the pelvis in the coronal and sagittal planes
③ M. adductor brevis	R. inferior ossis pubis		N. obturatorius (L2, L3)	
④ M. gracilis	R. inferior ossis pubis	Tibia (medial border of the tuberositas tibiae, along with the tendons of m. sartorius and m. semitendinosus)		• Articulatio coxae: adduction and flexion • Articulatio genus: flexion and internal rotation

Fig. 24.25 **Medial group: Deep layer**
Right side, anterior view.



A Schematic.



B Deep adductor group.

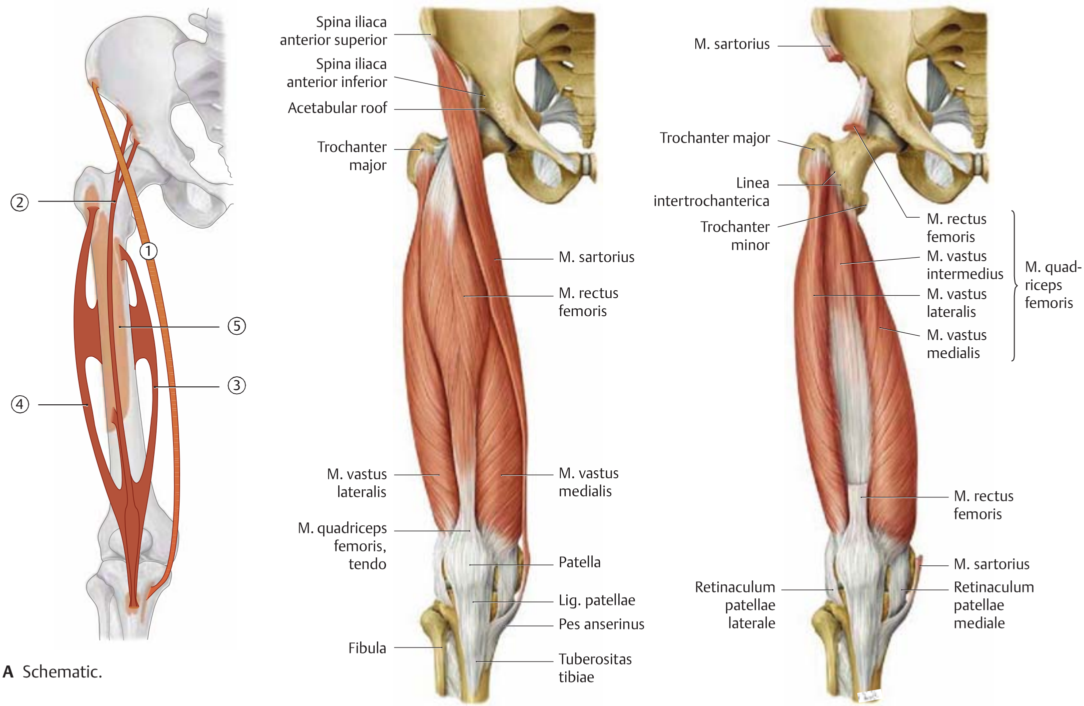
Table 24.4 **Medial thigh muscles: Deep layer**

Muscle	Origin	Insertion	Innervation	Action
① M. obturatorius externus	Outer surface of membrana obturatoria and its bony boundaries	Fossa trochanterica	N. obturatorius (L3, L4)	• Articulatio coxae: adduction and external rotation • Stabilizes the pelvis in the sagittal plane
② M. adductor minimus	R. inferior ossis pubis	Labium mediale of linea aspera	N. obturatorius (L2–L4)	Articulatio coxae: adduction extension, and slight flexion of the hip joint
③ M. adductor magnus	R. inferior ossis pubis, r. ossis ischii, tuber ischiadicum	• Pars profunda ("fleshy insertion"): labium mediale of linea aspera • Pars superficiale ("tendinous insertion"): tuberculum adductorium	• Pars profundus: N. obturatorius (L2–L4) • Pars superficiale: N. tibialis (L4)	• Articulatio coxae: adduction, extention, and slight flexion (the tendinous insertion is also active in internal rotation) • Stabilizes the pelvis in the coronal and sagittal plane

Muscle Facts (III)

The anterior and posterior muscles of the thigh can be classified as extensors and flexors, respectively, with regard to the knee joint.

Fig. 24.26 **Anterior thigh muscles**
Right side, anterior view.



A Schematic.

B Superficial group.

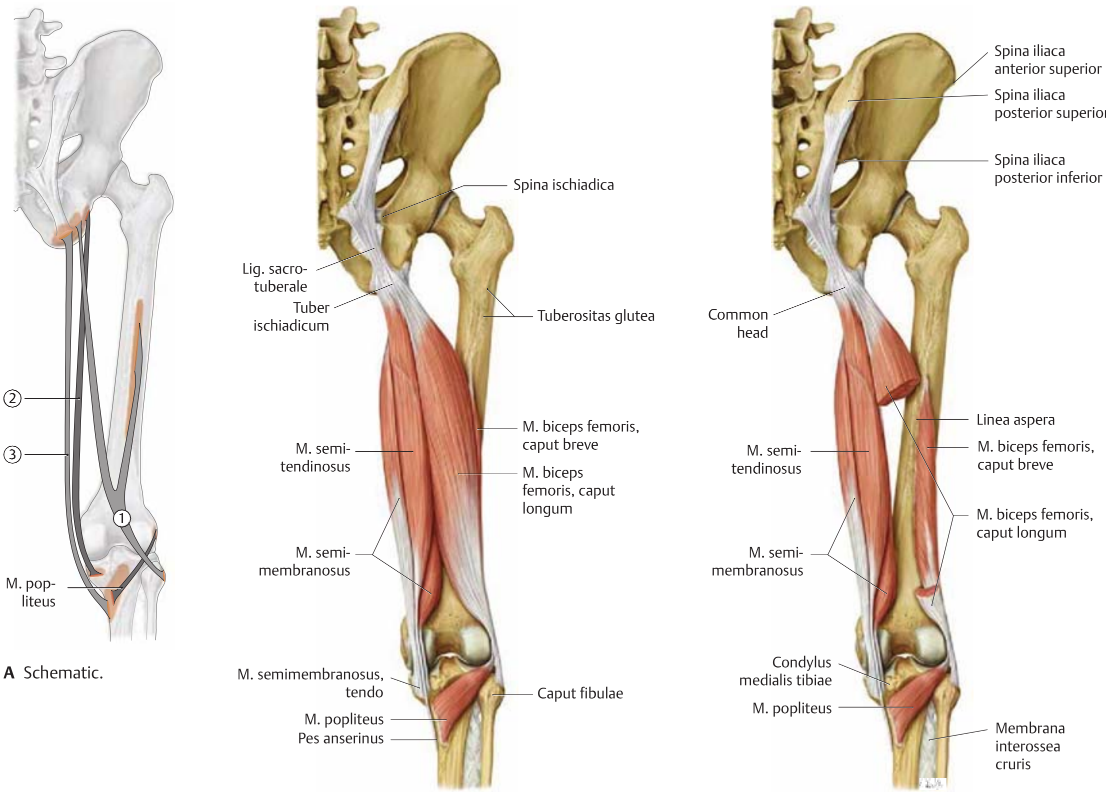
C Deep group. *Removed:* M. sartorius and m. rectus femoris.

Table 24.5 **Anterior thigh muscles**

Muscle		Origin	Insertion	Innervation	Action
① M. sartorius		Spina iliaca anterior superior	Medial to tuberositas tibiae (together with m. gracilis and m. semitendinosus)	N. femoralis (L2, L3)	• Articulatio coxae: flexion, abduction, and external rotation • Articulatio genus: flexion and internal rotation
M. quadriceps femoris*	② M. rectus femoris	Spina iliaca anterior inferior, acetabular roof of articulatio coxae	Tuberositas tibiae (via lig. patellae)	N. femoralis (L2–L4)	• Articulatio coxae: flexion • Articulatio genus: extension
	③ M. vastus medialis	Labium mediale of linea aspera, linea intertrochanterica	Both sides of tuberositas tibiae on the condylus medialis and lateralis (via the medial and longitudinal retinacula patellae)		Articulatio genus: extension
	④ M. vastus lateralis	Labium laterale of linea aspera, trochanter major (lateral surface)			
	⑤ M. vastus intermedius	fascies anterior of femur	Tuberositas tibiae (via lig. patellae)		
	M. articularis genus	Fascies anterior of femoral shaft at level of the recessus suprapatellaris	Recessus suprapatellares of knee joint capsule		Articulatio genus: extension; prevents entrapment of capsule

*The entire muscle inserts on the tibial tuberosity via the patellar ligament.

Fig. 24.27 **Posterior thigh muscles**
Right side, posterior view.



A Schematic.

B Superficial group.

C Deep group. *Removed:* M. biceps femoris (long head) and m. semitendinosus.

Table 24.6 **Posterior thigh muscles**

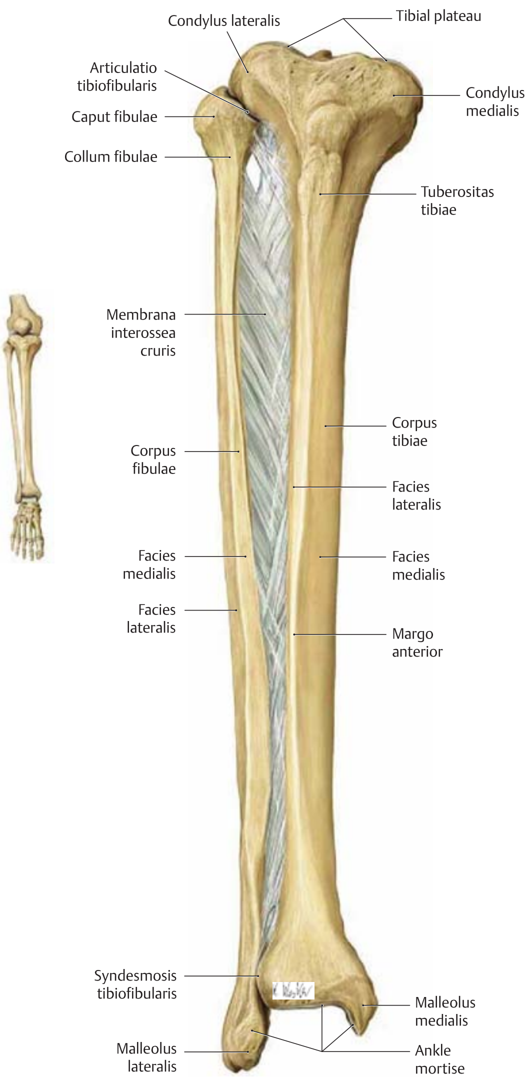
Muscle	Origin	Insertion	Innervation	Action
① M. biceps femoris	Caput longum: tuber ischiadicum, lig. sacrotuberale (common head with m. semitendinosus)	Caput fibulae	N. tibialis (L5–S2)	• Articulatio coxae (long head): extends the hip, stabilizes the pelvis in the sagittal plane • Articulatio genus: flexion and external rotation
	Caput breve: labium laterale of linea aspera (in the middle third of the femur)		N. fibularis communis (L5–S2)	Articulatio genus: flexion and external rotation
② M. semimembranosus	Tuber ischiadicum	Condylus medialis of tibia, lig. popliteum obliquum, fascia poplitea	N. tibialis (L5–S2)	• Articulatio coxae: extends the hip, stabilizes the pelvis in the sagittal plane • Articulatio genus: flexion and internal rotation
③ M. semitendinosus	Tuber ischiadicum, lig. sacrotuberale (common head with long head of m. biceps femoris)	Medial to tuberositas tibiae, pes anserinus (along with the tendons of m. gracilis and m. sartorius)		

See p. 399 for m. popliteus.

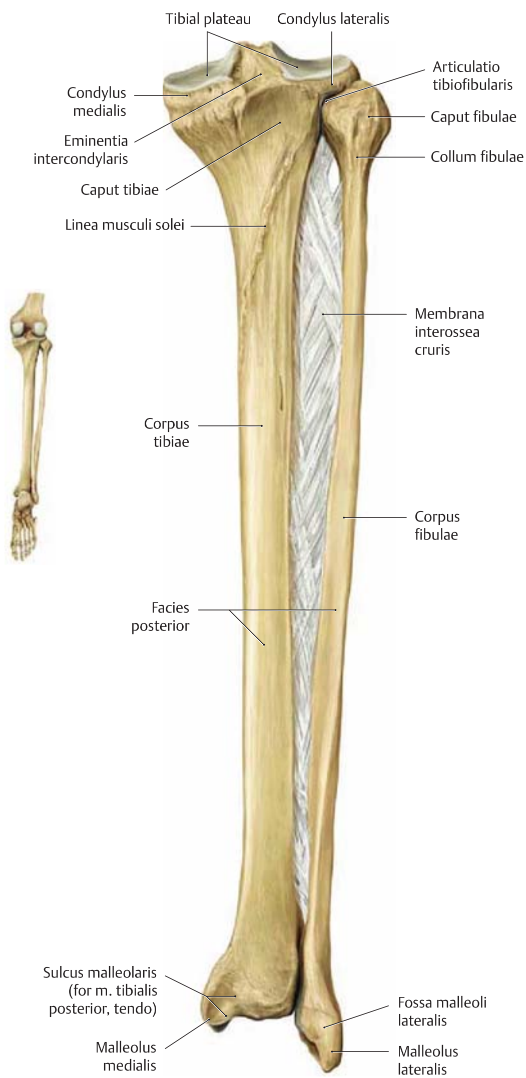
Tibia & Fibula

The tibia and fibula articulate at two joints, allowing limited motion (rotation). Membrana interossea cruris is a sheet of tough connective tissue that serves as an origin for several muscles in the leg. It also acts with syndesmosis tibiofibularis to stabilize articulatio talocruralis.

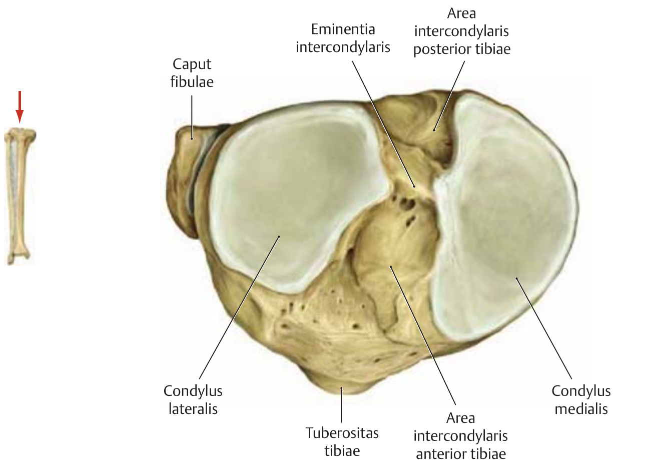
Fig. 25.1 **Tibia and fibula**
Right leg.



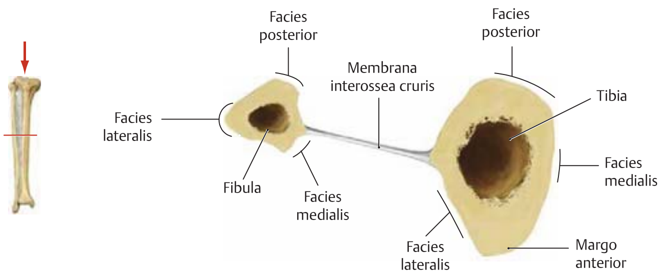
A Anterior view.



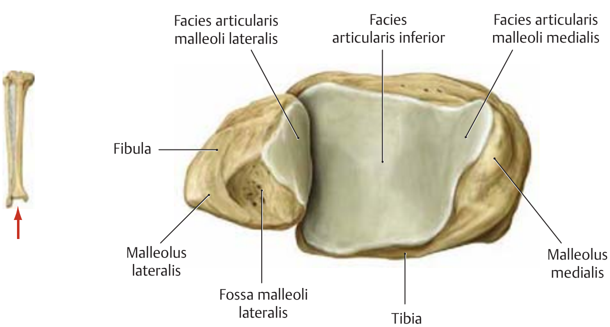
B Posterior view.



C Proximal view.



D Transverse section, superior view.

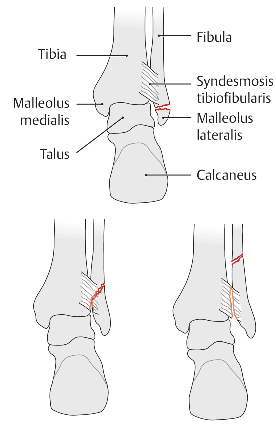


E Distal view.

Clinical

Fibular fracture

When diagnosing a fibular fracture, it is important to determine whether the syndesmosis (see p. 380) is disrupted. Fibular fractures may occur distal to, level with, or proximal to the syndesmosis; the latter two frequently involve tearing of the syndesmosis.

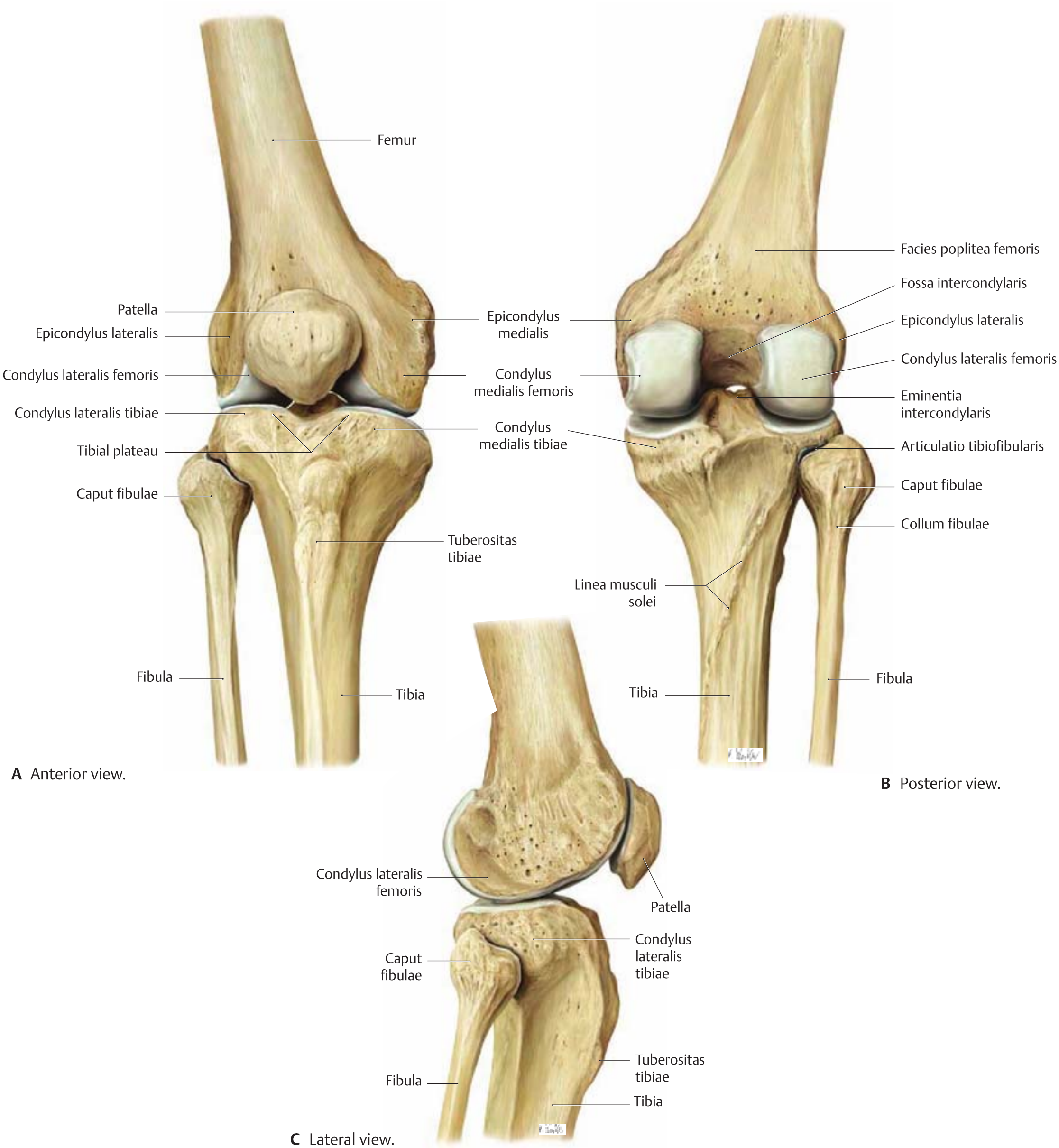


In this fracture, located proximal to the syndesmosis, the syndesmosis is torn, as indicated by the widened medial joint space of the articulatio talocruralis (see p. 405).

Articulatio Genus: Overview

In articulatio genus, the femur articulates with the tibia and patella. Both joints are contained within a common capsule and have communicating articular cavities. *Note:* The fibula is not included in the knee joint (contrast to the humerus in the elbow; see p. 282). Instead, it forms a separate rigid articulation with the tibia.

Fig. 25.2 **Right articulatio genus**



A Anterior view.

B Posterior view.

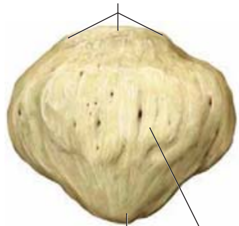
C Lateral view.

Fig. 25.3 Articulatio genus: Radiographs

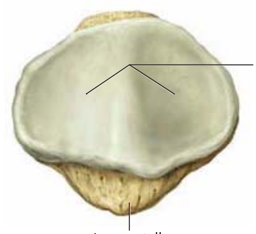
A Anteroposterior projection.

B Lateral projection.

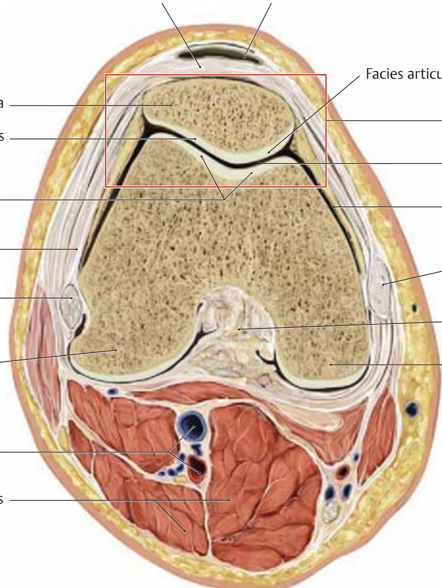
Fig. 25.4 Patella



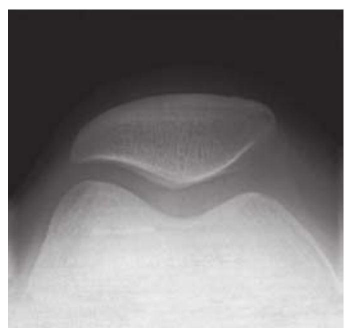
A Anterior view.



B Posterior view.



C Transverse section through femoro-patellar joint. Distal view with right knee in slight flexion.



D Radiographic view of patella and femoral trochlea. Tangential radiographic view with right knee in 60 degrees of flexion ("sunrise" view). Note the width of the joint space due to the thick articular cartilage.

Articulatio Genus: Capsule, Ligaments & Bursae

Table 25.1	**Ligaments of the knee joint**
Extrinsic ligaments	
Anterior side	Lig. patellae
	Retinaculum patellae mediale longitudinale
	Retinaculum patellae laterale longitudinale
	Retinaculum patellae mediale transversale
	Retinaculum patellae laterale transversale
Medial and lateral sides	Lig. collaterale tibiale
	Lig. collaterale fibulare
Posterior side	Lig. popliteum obliquum
	Lig. popliteum arcuatum
Intrinsic ligaments	
Lig. cruciatum anterius	
Lig. cruciatum posterius	
Lig. transversum genus	
Lig. meniscofemorale posterius	

Fig. 25.5 **Ligaments of articulatio genus**
Anterior view of right knee.

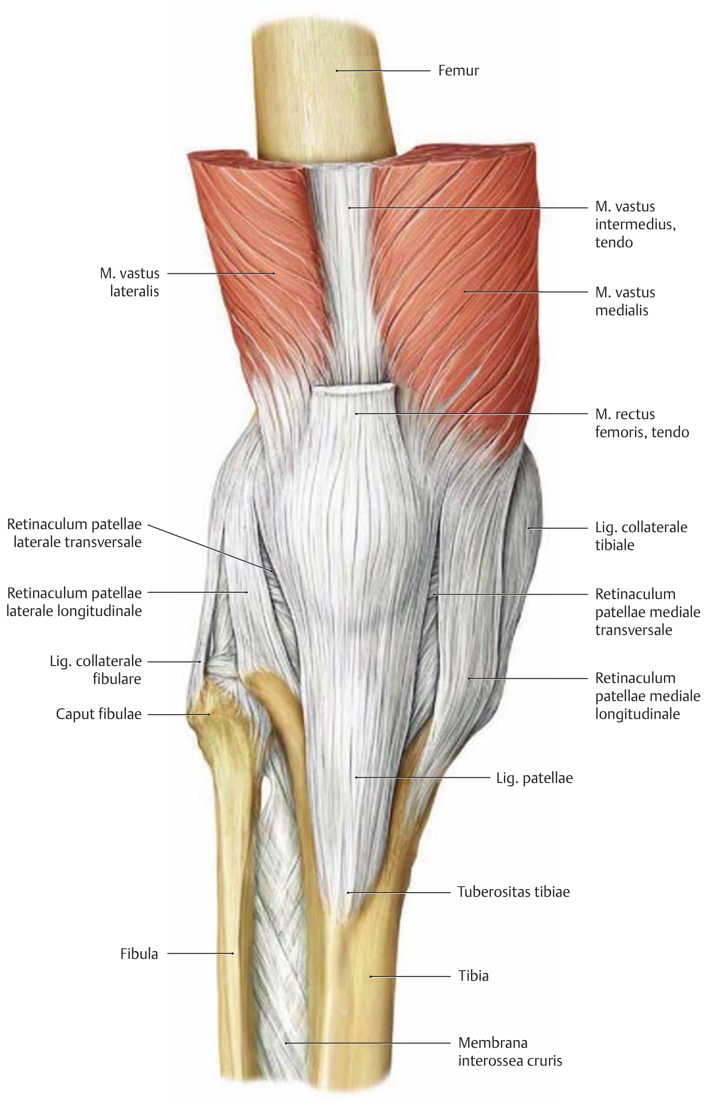
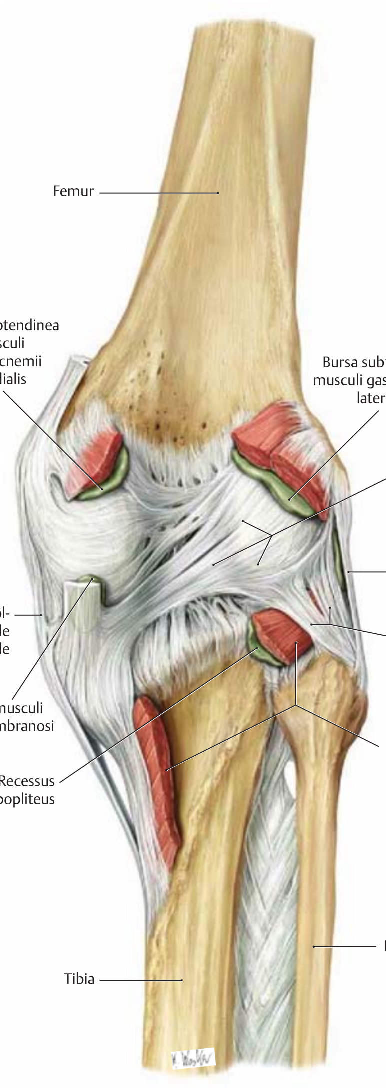
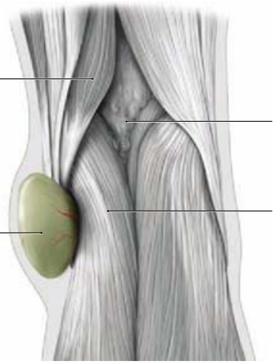


Fig. 25.6 **Capsule, ligaments, and periarticular bursae**
Posterior view of right knee. The joint cavity communicates with periarticular bursae at the subpopliteal recess, semimembranosus bursa, and medial subtendinous bursa of m. gastrocnemius.



Clinical

Gastrocnemio-semimembranosus bursa (Baker's cyst)
Painful swelling behind the knee may be caused by a cystic outpouching of the joint capsule (synovial popliteal cyst). This frequently results from a rise in intra-articular pressure (e.g., in rheumatoid arthritis).

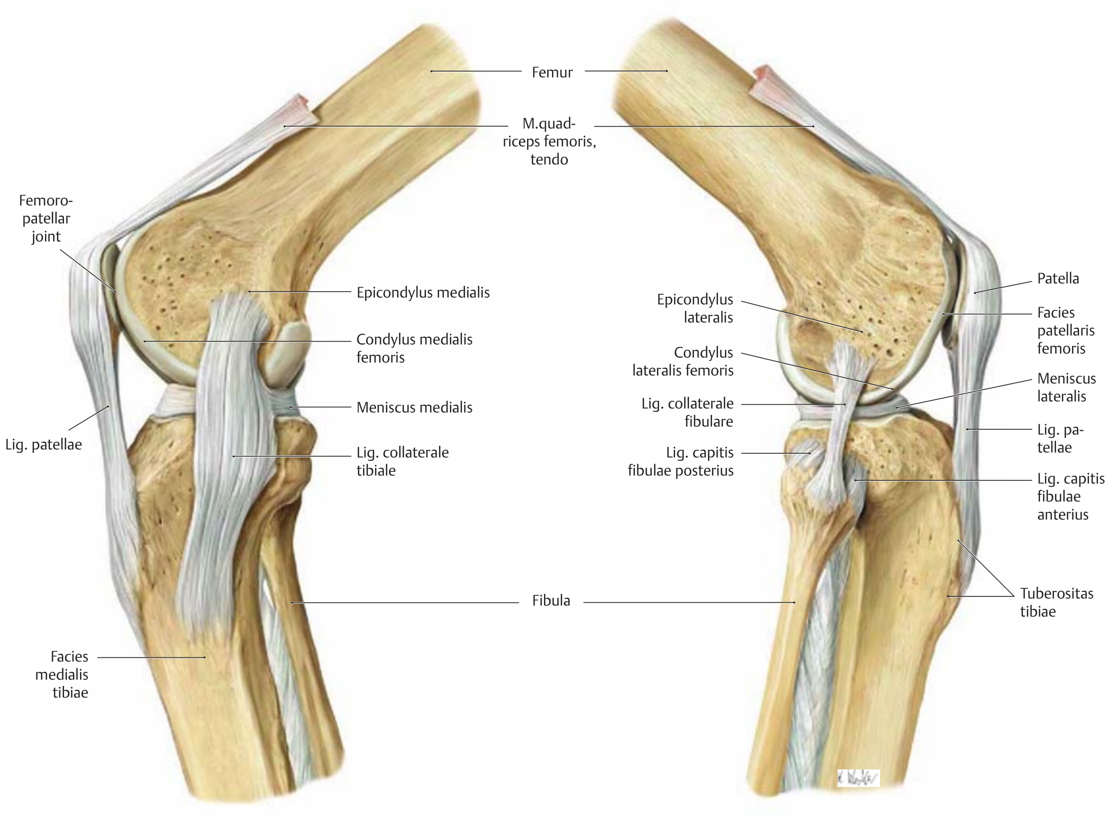


A Baker's cyst in the right fossa poplitea. Baker's cysts often occur in the medial part of fossa poplitea between m. semimembranosus tendon and caput mediale of m. gastrocnemius at the level of the posteromedial condylus femoris.

B Axial magnetic resonance imaging (MRI) of a Baker's cyst in fossa poplitea, inferior view.

Articulatio Genus: Ligaments & Menisci

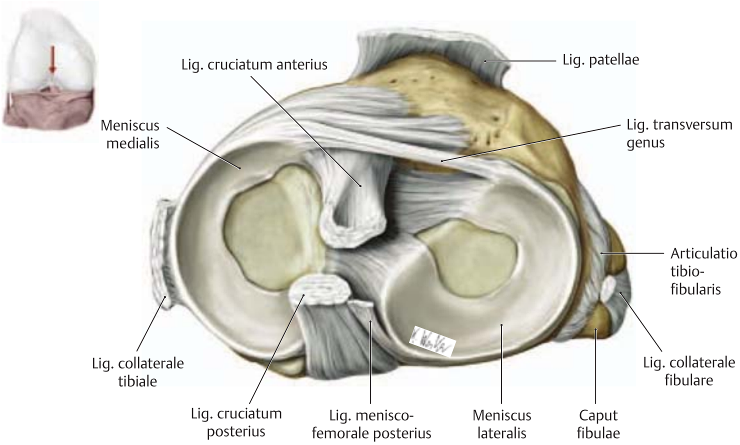
Fig. 25.7 **Collateral and patellar ligaments of articulatio genus**
Right articulatio genus. Each articulatio genus has medial and lateral collateral ligaments. The medial collateral ligament (lig. collaterale tibiale) is attached to both the capsule and meniscus medialis, whereas the lig. collateral fibulare has no direct contact with either the capsule or the lateral meniscus. Both collateral ligaments are taut when the knee is in extension and stabilize the joint in the coronal plane.



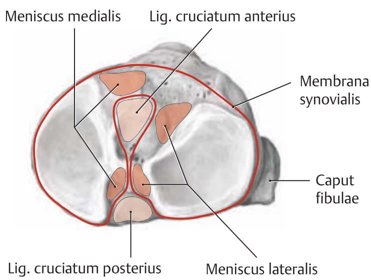
A Medial view.　**B** Lateral view.

Fig. 25.8 Menisci in articulatio genus

Right tibial plateau, proximal view.



A Right tibial plateau with ligg. cruciata, lig. patellae, and ligg. collaterale tibiale and fibulare divided.



B Attachment sites of menisci and ligg. cruciata. Red line indicates the tibial attachment of membrana synovialis that covers ligg. cruciata. The ligg. cruciata lie in the subsynovial connective tissue.

Clinical

Injury of the menisci

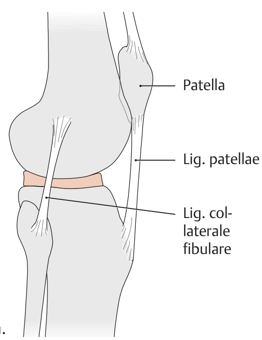
The less mobile meniscus medialis is more susceptible to injury than meniscus lateralis. Trauma generally results from sudden extension or rotation of the flexed knee while the leg is fixed.

A Bucket-handle tear.

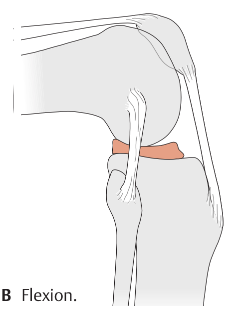
B Radial tear of posterior horn.

Fig. 25.9 Movements of the menisci

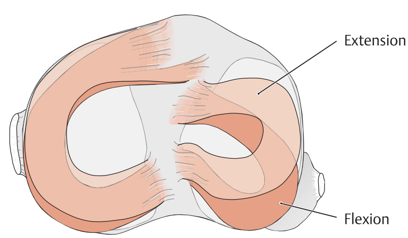
Right knee joint.



A Extension.



B Flexion.

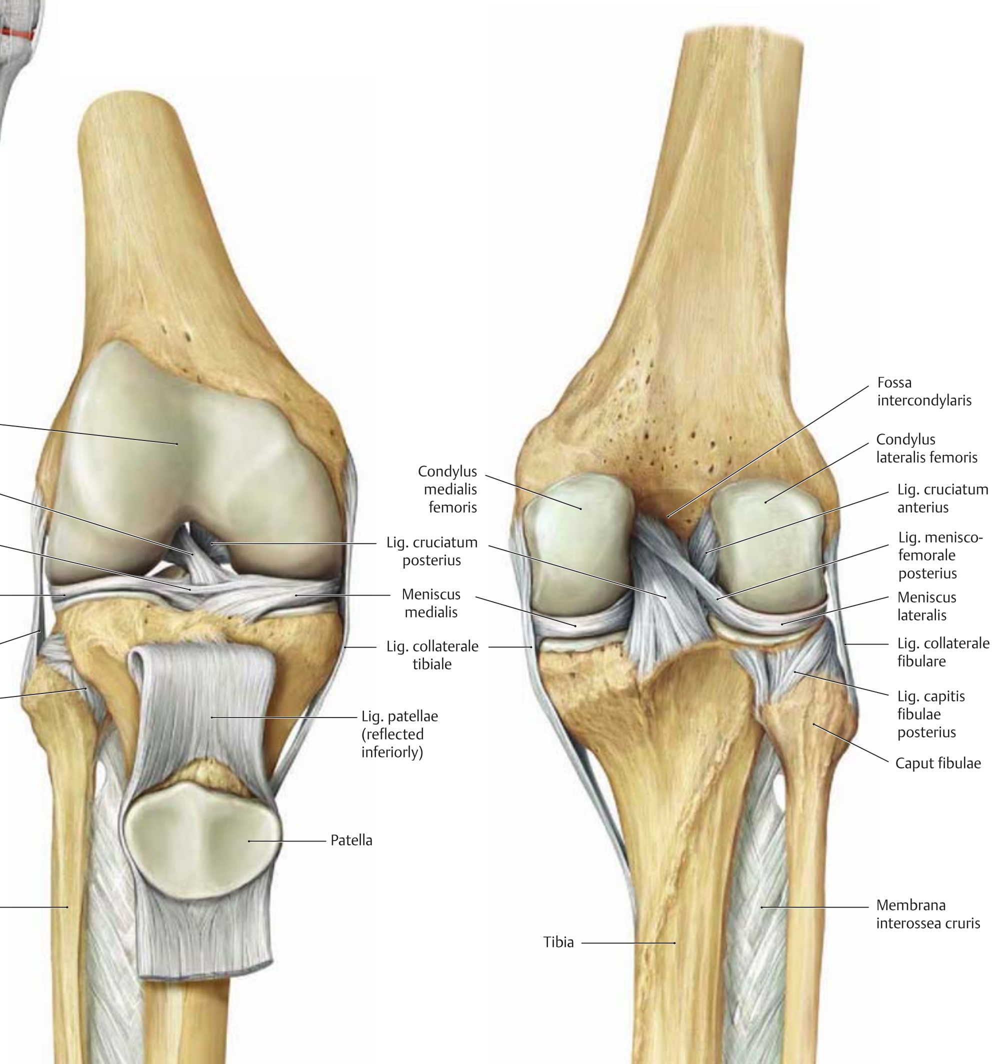


C Tibial plateau, proximal view.

Ligamenta Cruciata

Fig. 25.10 **Ligg. cruciata and collateralia**

Right articulatio genus. Ligg. cruciata keep the articular surfaces of the femur and tibia in contact, while stabilizing the knee joint primarily in the sagittal plane. Portions of ligg. cruciata are taut in every joint position.



A Anterior view.

B Posterior view.

Fig. 25.11 **Right articulatio genus in flexion**
Anterior view with capsula articularis and patella removed.

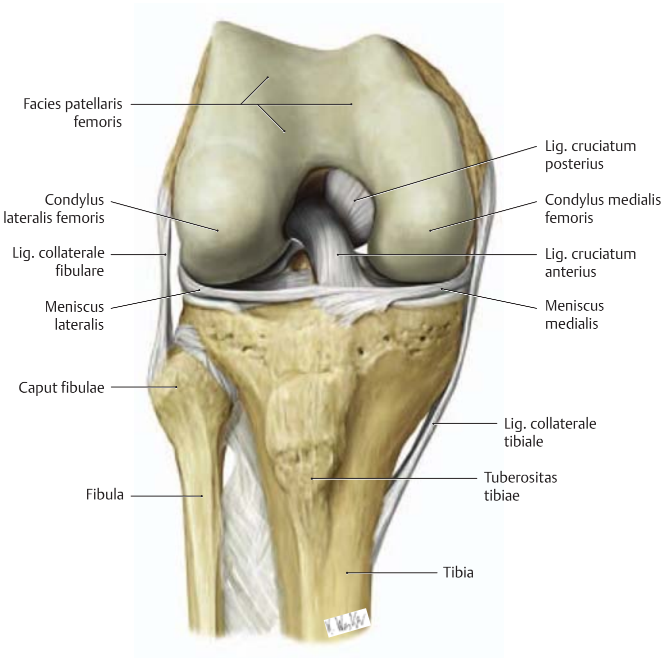
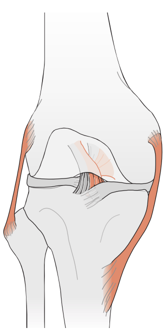
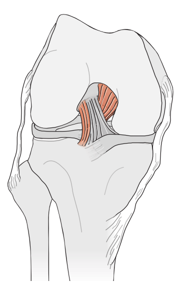


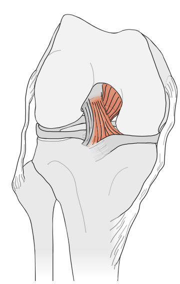
Fig. 25.12 **Ligg. cruciata and collateralia in flexion and extension**
Right knee, anterior view. Taut ligament fibers in red.



A Extension.



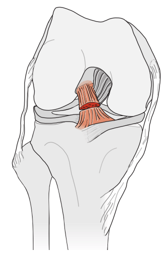
B Flexion.



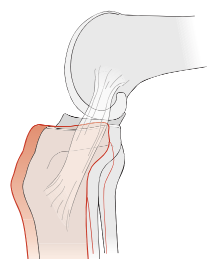
C Flexion and internal rotation.

Clinical

Rupture of ligg. cruciata
Rupture of ligg. cruciata destabilizes the knee joint, allowing the tibia to move forward (anterior "drawer sign") or backward (posterior "drawer sign") relative to the femur. Lig. cruciata anterius ruptures are approximately 10 times more common than posterior ligament ruptures. The most common mechanism of injury is an internal rotation trauma with the leg fixed. A lateral blow to the fully extended knee with the foot planted tends to cause concomitant rupture of lig. cruciatum anterius and lig. collaterale tibiale, as well as tearing of the attached meniscus medialis.



A Rupture of lig. cruciatum anterius. Anterior view.



B "Anterior drawer sign." Medial view.

Right knee joint in flexion.

Articulatio Genus Cavitas Articularis

Fig. 25.13 **Cavitas articularis**
Right knee, lateral view. Cavitas articularis was demonstrated by injecting liquid plastic into the knee joint and later removing the capsule.

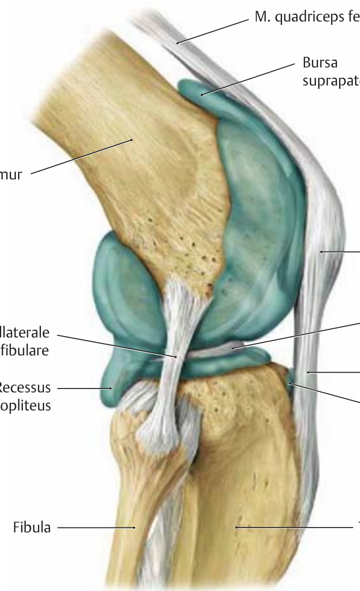


Fig. 25.15 **Attachments of capsula articularis**
Right knee joint, anterior view.

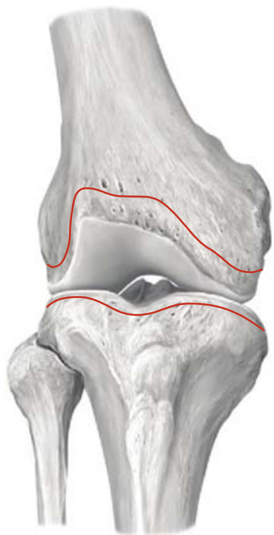


Fig. 25.14 **Opened capsula articularis**
Right knee, anterior view with patella reflected downward.

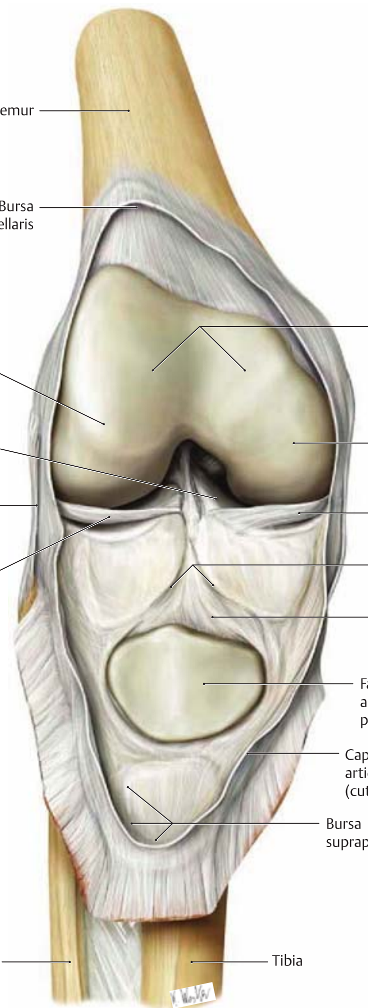
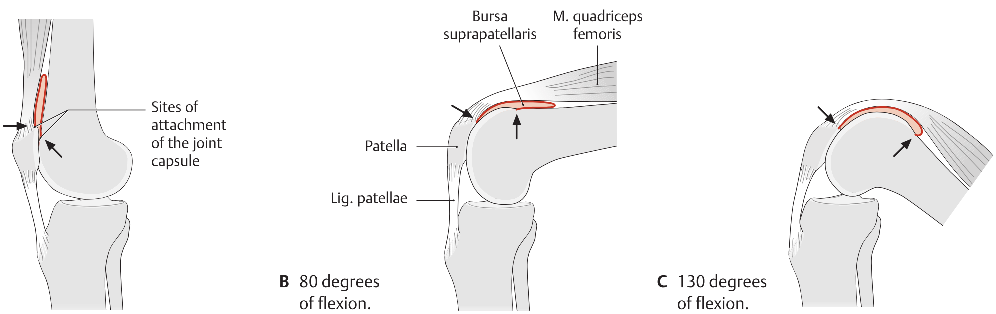


Fig. 25.16 **Bursa suprapatellaris during flexion**
Right knee joint, medial view.



A Neutral (0-degree) position.

B 80 degrees of flexion.

C 130 degrees of flexion.

Fig. 25.17 **Right knee joint: Midsagittal section**

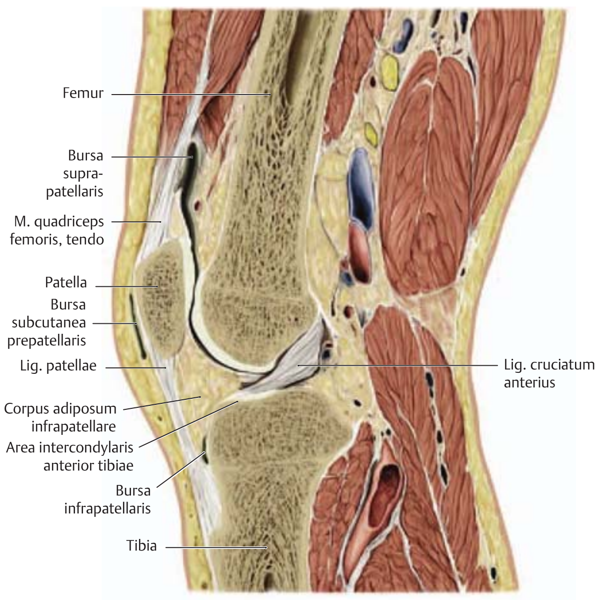
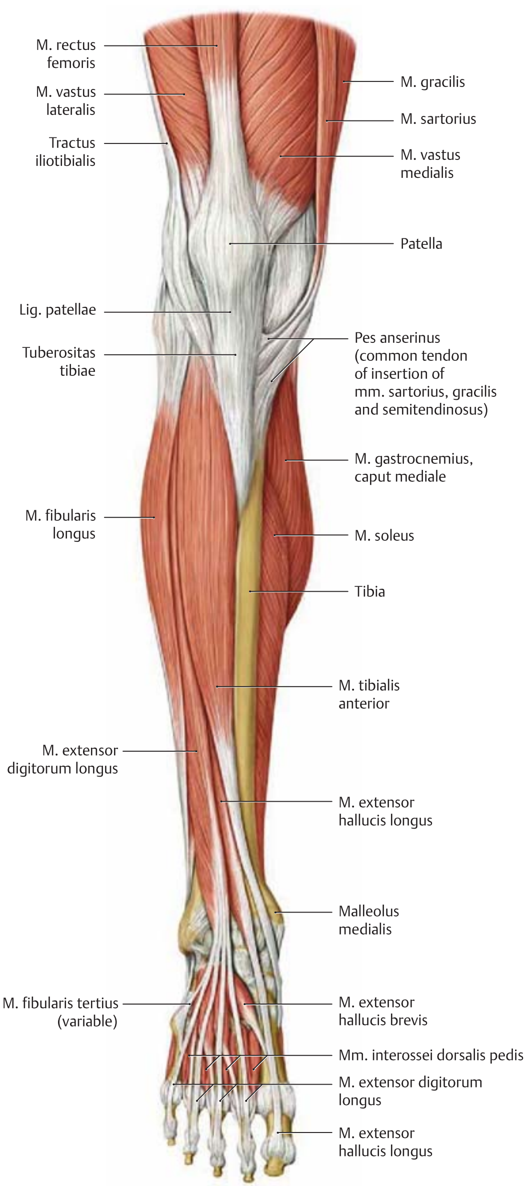


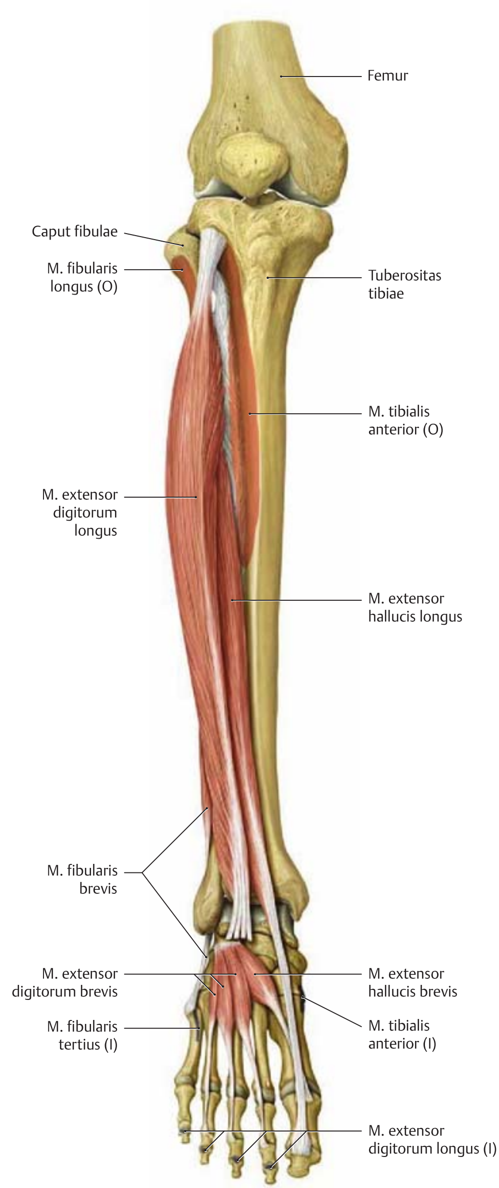
Fig. 25.18 **MRI of articulatio genus**
Sagittal T2-weighted MRI.

Muscles of the Leg: Anterior & Lateral Views

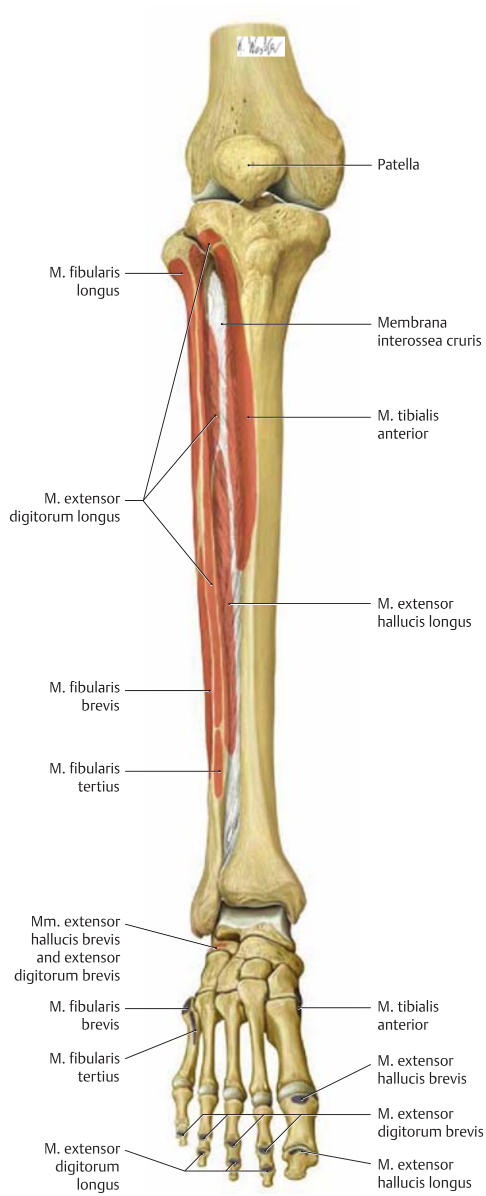
Fig. 25.19 **Muscles of the leg: Anterior view**
Right leg. Muscle origins (O) shown in red, insertions (I) in blue.



A All muscles shown.

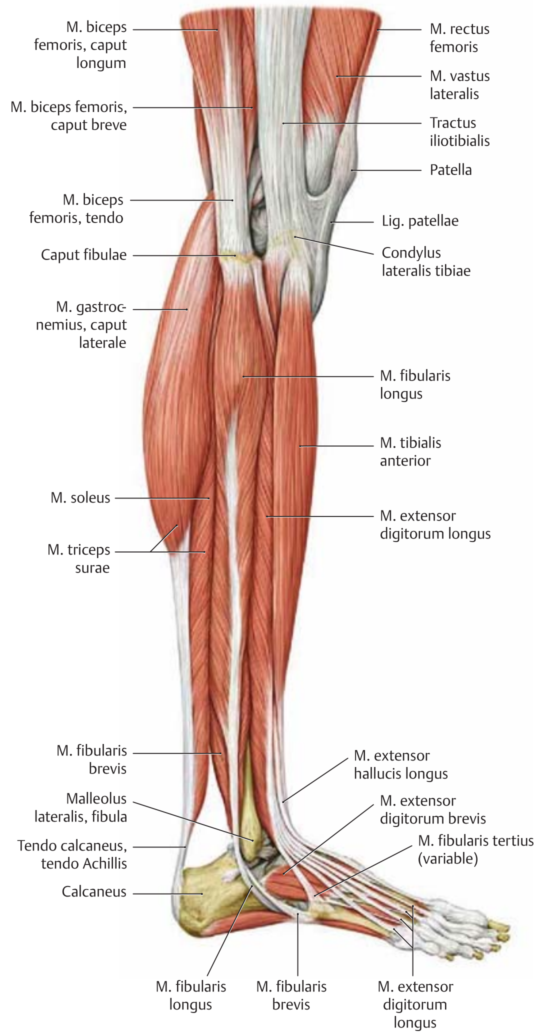


B *Removed:* M. tibialis anterior and m. fibularis longus; m. extensor digitorum longus tendons (distal portions). *Note*: M. fibularis tertius is a division of m. extensor digitorum longus.



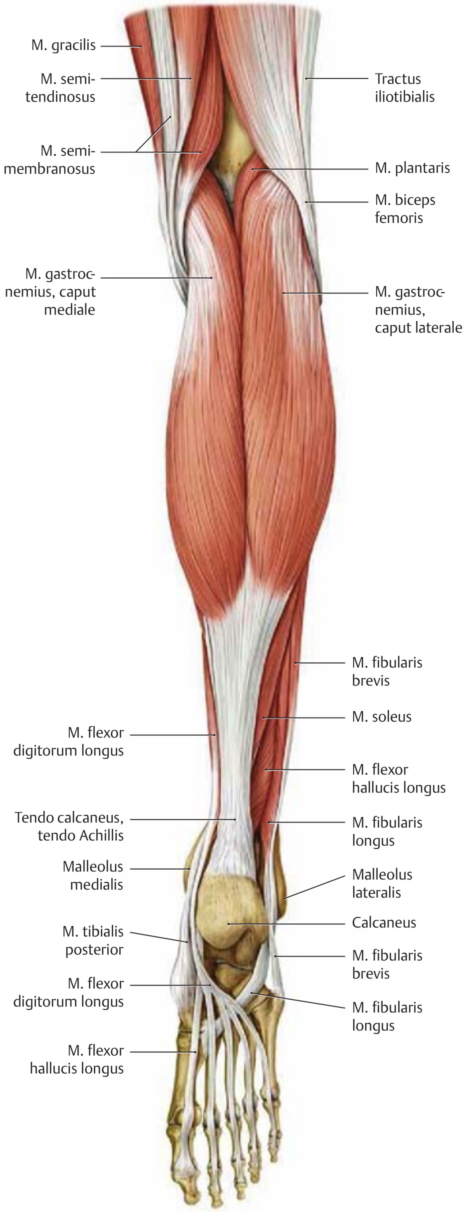
C *Removed:* All muscles.

Fig. 25.20 **Muscles of the leg: Lateral view**
Right leg.

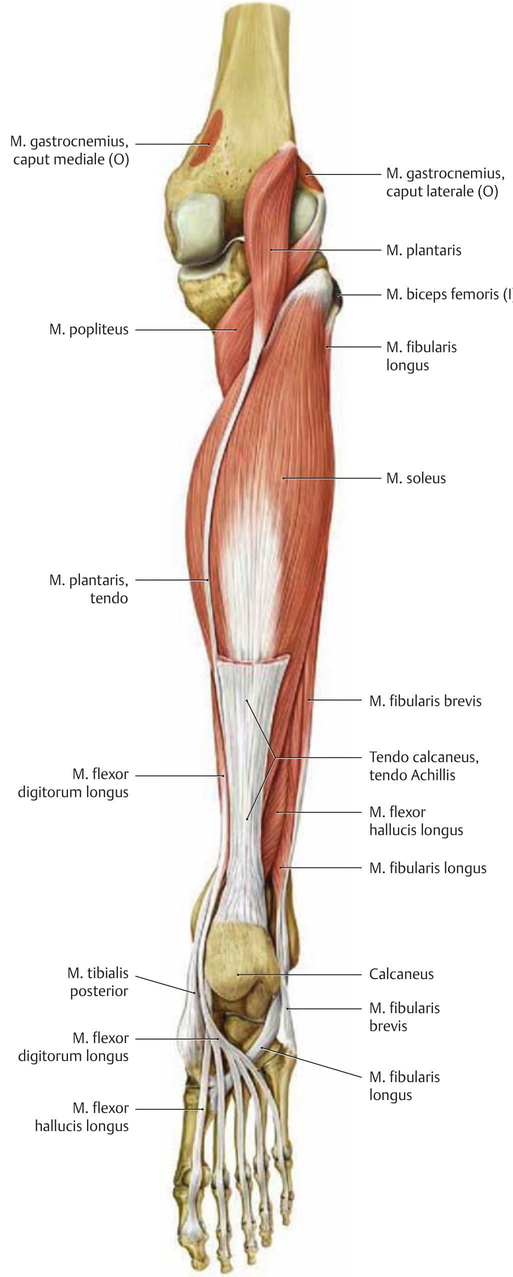


Muscles of the Leg: Posterior View

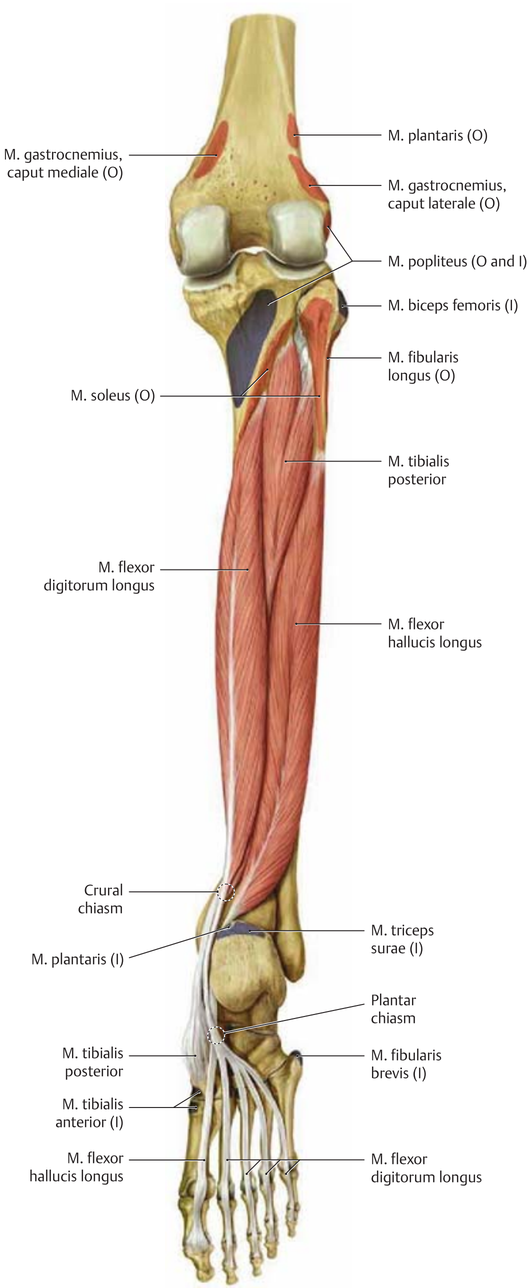
Fig. 25.21 **Muscles of the leg: Posterior view**
Right leg. Muscle origins (O) shown in red, insertions (I) in blue.



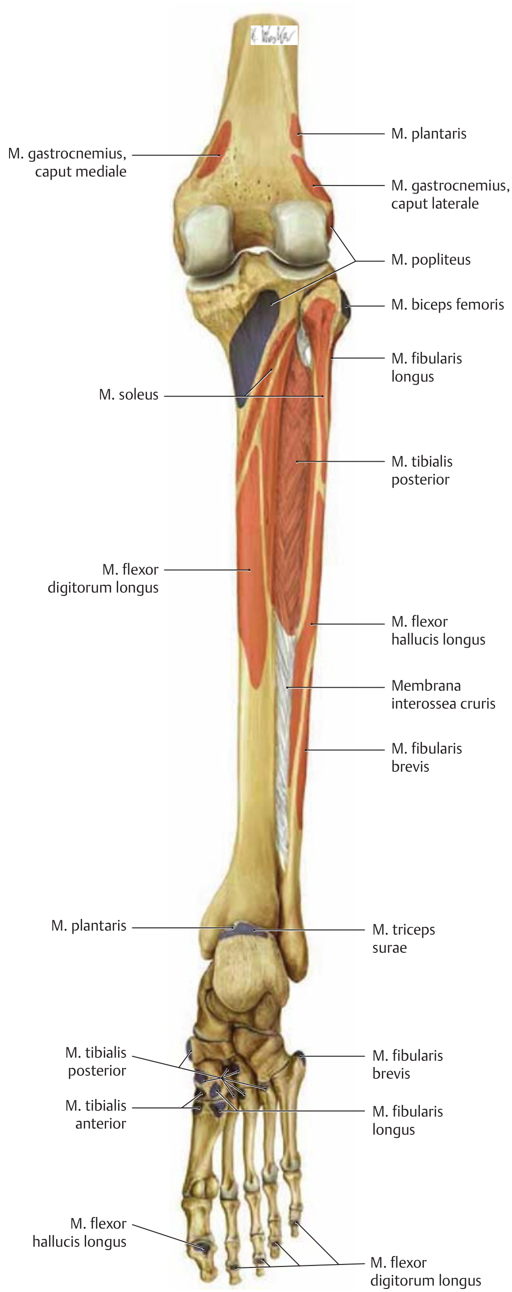
A *Note:* The bulge of the calf is produced mainly by m. triceps surae (m. soleus and the two heads of m. gastrocnemius).



B *Removed:* M. gastrocnemius (both heads).



C *Removed:* M. triceps surae, m. plantaris, m. popliteus, and m. fibularis longus.

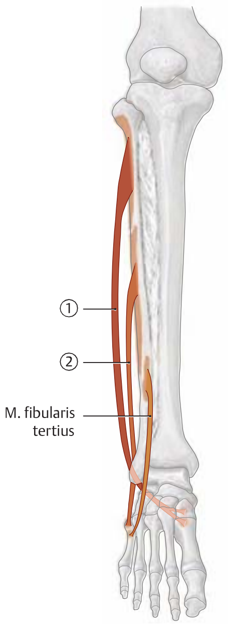


D *Removed:* All muscles.

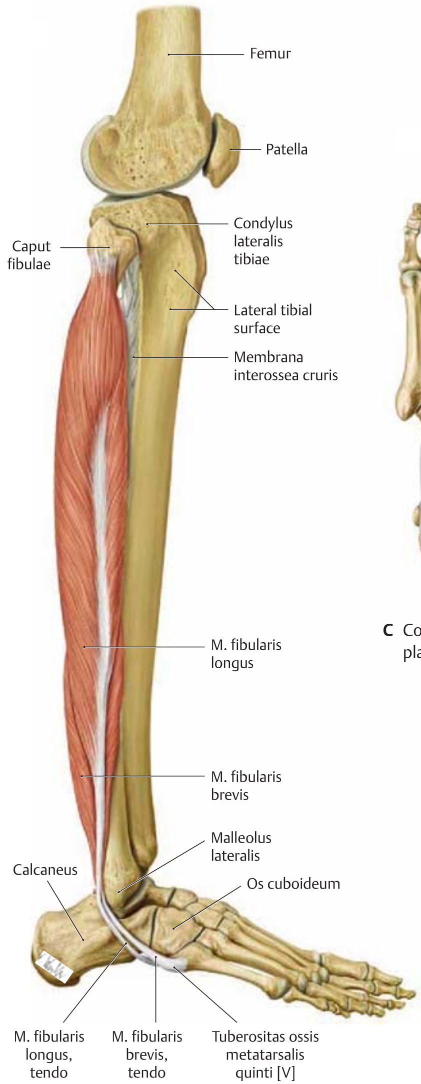
Muscle Facts (I)

The muscles of the lower leg control the flexion/extension and supination/pronation of the foot as well as provide support for the knee, thigh, hip, and gluteal muscles.

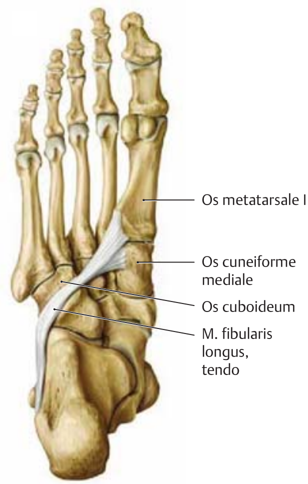
Fig. 25.22 **Lateral compartment**
Right leg and foot.



A Fibularis group, anterior view.



B Lateral compartment, right lateral view.

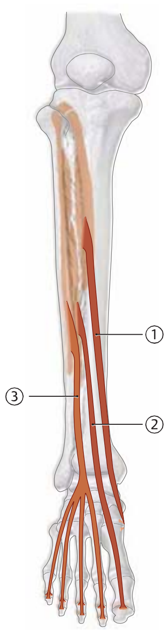


C Course of the fibularis longus tendon, plantar view.

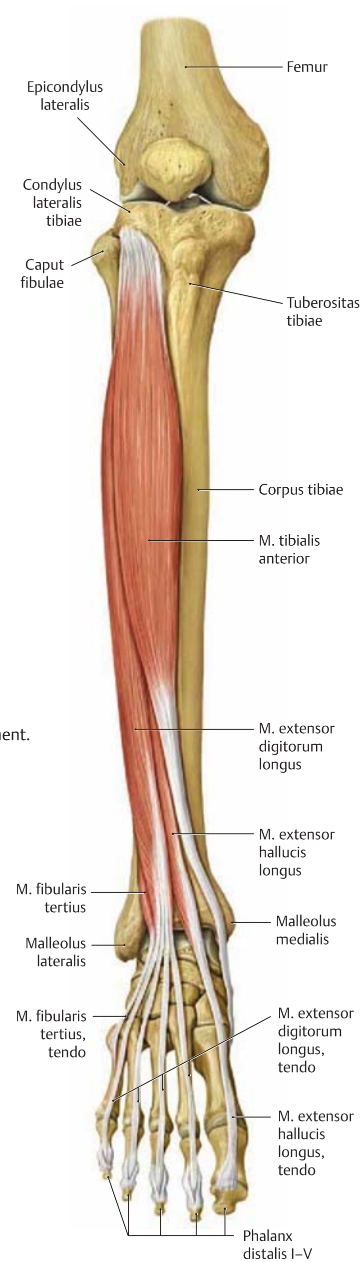
Table 25.2 **Lateral compartment**

Muscle	Origin	Insertion	Innervation	Action
① M. fibularis longus	Caput fibulae, facies lateralis and margo anterior of fibula, septa intermuscularia	Os cuneiforme intermedium (pars plantaris), tuberositas ossis metatarsi I	N. fibularis superficialis (L5, S1)	• Articulatio talocruralis: plantar flexion • Articulatio subtalaris: eversion (pronation) • Supports the transverse arch of the foot
② M. fibularis brevis	Fibula (distal half of the lateral surface), septa intermuscularia	Tuberositas ossis metatarsi V		• Articulatio talocruralis: plantar flexion • Articulatio subtalaris: eversion (pronation)

***Fig. 25.23* Anterior compartment**
Right leg, anterior view.



A Schematic.



B Anterior compartment.

Table 25.3 Anterior compartment

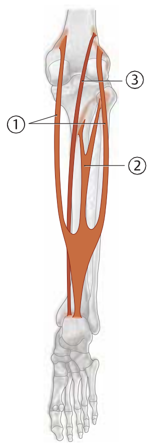
Muscle	Origin	Insertion	Innervation	Action
① M. tibialis anterior	Fascies lateralis of tibia (upper two thirds), membrana interossea, fascia cruris (highest part)	Os cuneiforme mediale (medial and plantar surface), medial base os metatarsi I	N. fibularis profundus (L4, L5)	• Articulatio talocruralis: dorsiflexion • Articulatio subtalaris: inversion (supination)
② M. extensor hallucis longus	Fascies medialis of fibula, membrana interossea	1st toe (aponeurosis dorsalis and the base of its phalanx distalis)	N. fibularis profundus (L5)	• Articulatio talocruralis: dorsiflexion • Articulatio subtalaris: active in both eversion and inversion (pronation/supination), depending on the initial position of the foot • Extends the MTP and IP joints of the big toe
③ M. extensor digitorum longus	Caput fibulae, fascies medialis of fibula, tibia (condylus lateralis), membrana interossea	2nd to 5th toes (at the aponeuroses dorsales and bases of the phalanx distalis)	N. fibularis profundus (L5, S1)	• Articulatio talocruralis: dorsiflexion • Articulatio subtalaris: eversion (pronation) • Extends the MTP and IP joints of the 2nd to 5th toes
M. fibularis tertius (see Fig. 25.22A)	Distal fibula (anterior border)	Os metatarsi I (base)	N. fibularis profundus (L5, S1)	• Articulatio talocruralis: dorsiflexion • Articulatio subtalaris: eversion (pronation)

IP = Articulationes interphalangeae pedis; MTP = Articulationes metatarsophalangeae.

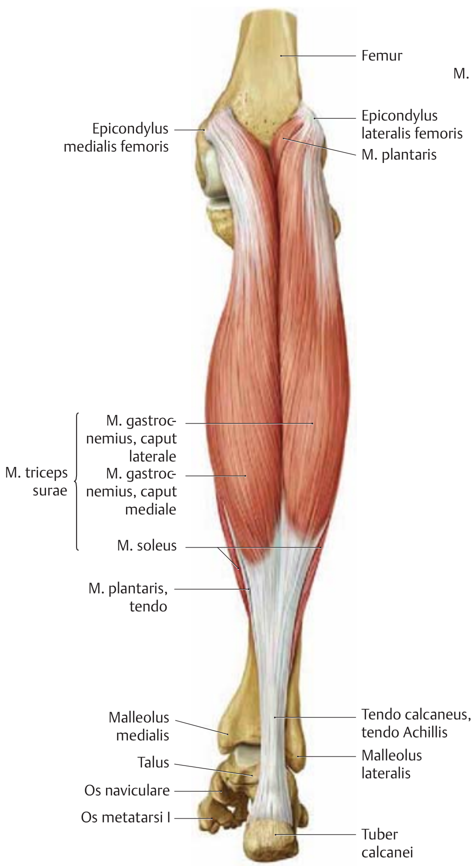
Muscle Facts (II)

The muscles of the posterior compartment are divided into two groups: the superficial and deep flexors. These groups are separated by the transverse intermuscular septum.

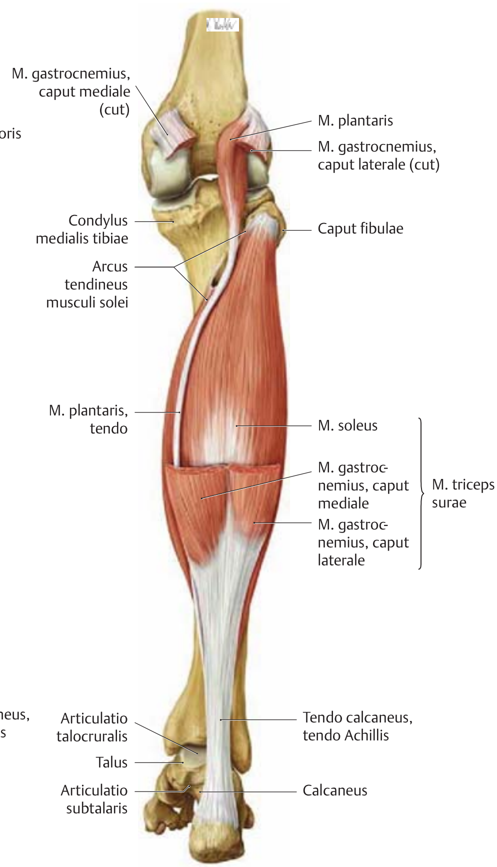
Fig. 25.24 Superficial flexors
Right leg, posterior view.



A Schematic. Foot in plantar flexion.



B Superficial flexors.



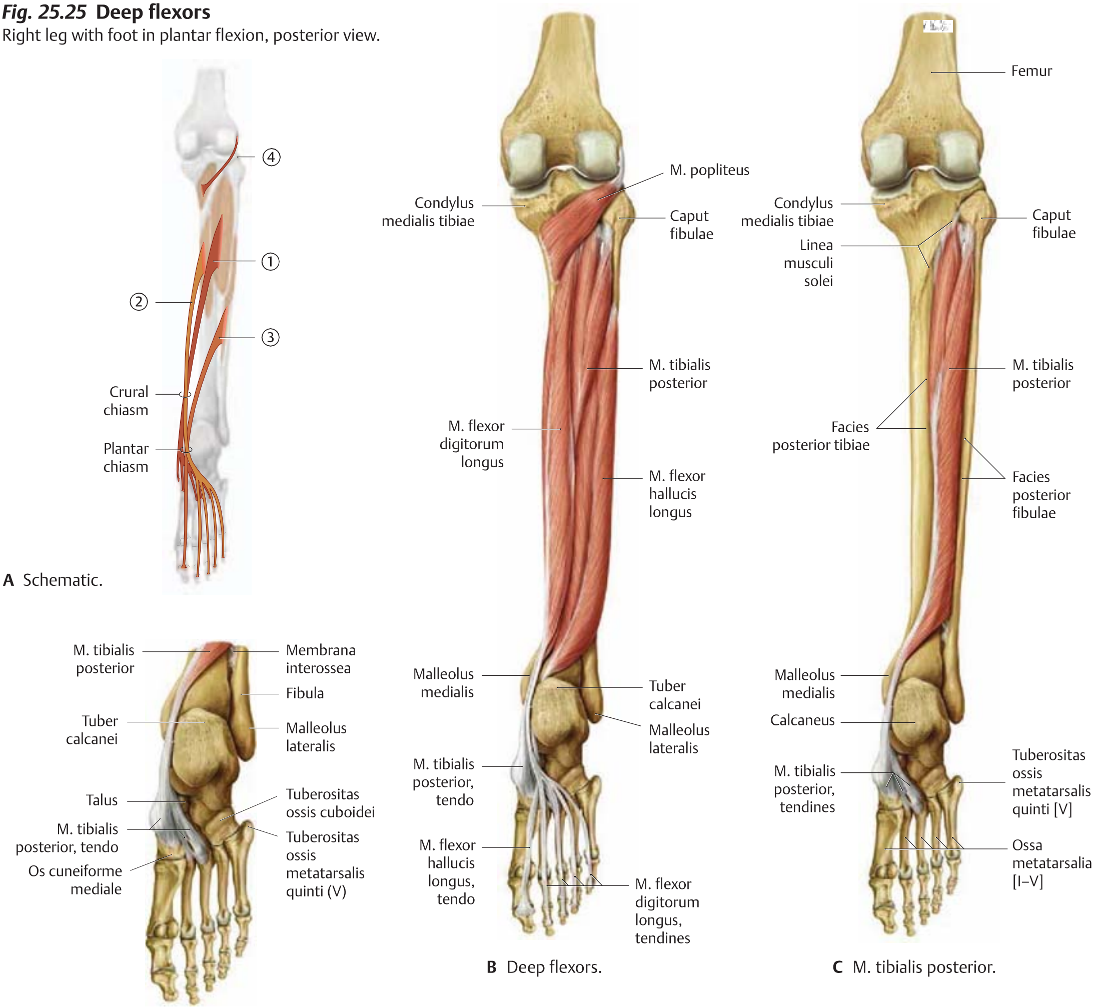
C Superficial flexors with m. gastrocnemius removed (portions of medial and lateral heads).

Table 25.4 Superficial flexors of the posterior compartment

Muscle		Origin	Insertion	Innervation	Action
M. triceps surae	① M. gastrocnemius	Femur (epicondylus medialis and lateralis)	Tuber calcanei via tendo calcaneus	N. tibialis (S1, S2)	• Articulatio talocruralis: plantar flexion • Articulatio genus: flexion (m. gastrocnemius)
	② M. soleus	Caput fibula, facies posterior and margo posterior of fibula, tibia, arcus tendineus musculi solei			
③ M. plantaris		Femur (epicondylus lateralis, proximal to caput laterale of m. gastrocnemius)			Negligible; may prevent compression of posterior leg musculature during knee flexion

Fig. 25.25 Deep flexors

Right leg with foot in plantar flexion, posterior view.



A Schematic.

B Deep flexors.

C M. tibialis posterior.

D Insertion of the m. tibialis posterior.

Table 25.5 **Deep flexors of the posterior compartment**

Muscle	Origin	Insertion	Innervation	Action
① M. tibialis posterior	Membrana interossea, fascies posterior of tibia and fibula	Tuberositas ossis navicularis; ossa cuneiforme, ossa metatarsi II–IV (bases)	N. tibialis (L4, L5)	• Articulatio talocruralis: plantar flexion • Articulatio subtalaris: inversion (supination) • Supports the longitudinal and transverse arches
② M. flexor digitorum longus	Tibia (fascies posterior)	Phalanx distalis II–V (bases)	N. tibialis (L5–S2)	• Articulatio talocruralis: plantar flexion • Articulatio subtalaris: inversion (supination) • MTP and IP joints of the 2nd to 5th toes: plantar flexion
③ M. flexor hallucis longus	Fibula (facies posterior, distal two thirds), membrana interossea	Phalanx distalis I (base)		• Articulatio talocruralis: plantar flexion • Articulatio subtalaris: inversion (supination) • MTP and IP joints of the 2nd to 5th toes: plantar flexion • Supports the medial longitudinal arch
④ M. popliteus	Epicondylus lateralis of femur, posterior horn of the meniscus lateralis	Tibia (facies posterior, above the origin at the m. soleus)	N. tibialis (L4–S1)	Articulatio genus: flexion and internal rotation (stabilizes the knee)

IP = Articulationes interphalangeae pedis; MTP = Articulationes metatarsophalangeae.

Ossa Pedis

Fig. 26.1 Subdivisions of the pedal skeleton

Right foot, dorsal view. Descriptive anatomy divides the skeletal elements of the foot into the tarsus, metatarsus, and forefoot (antetarsus). Functional and clinical criteria divide the pedal skeleton into hindfoot, midfoot, and forefoot.

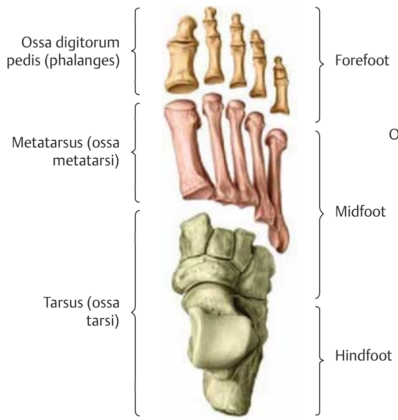
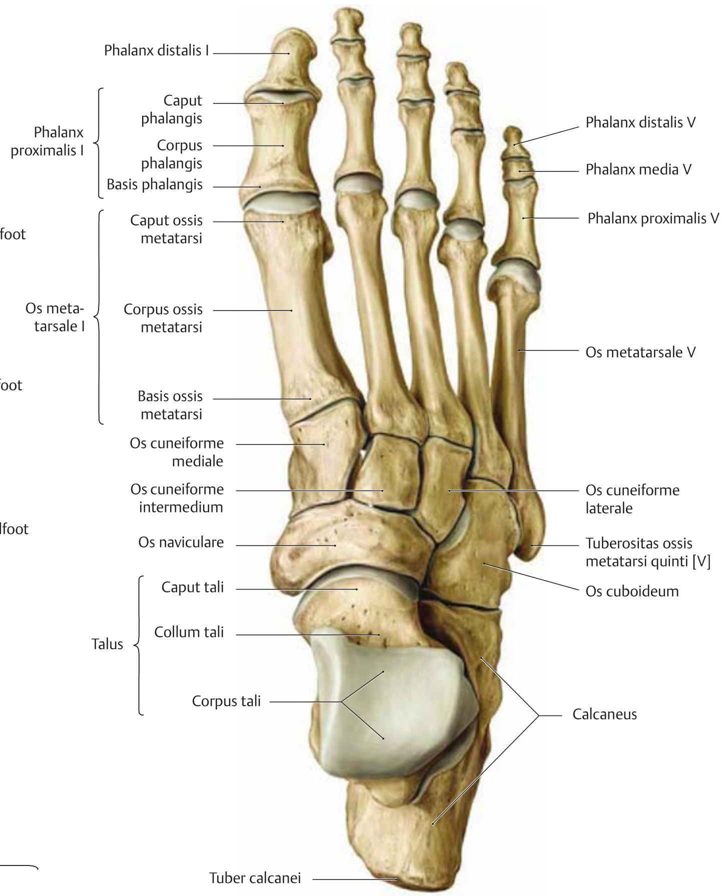
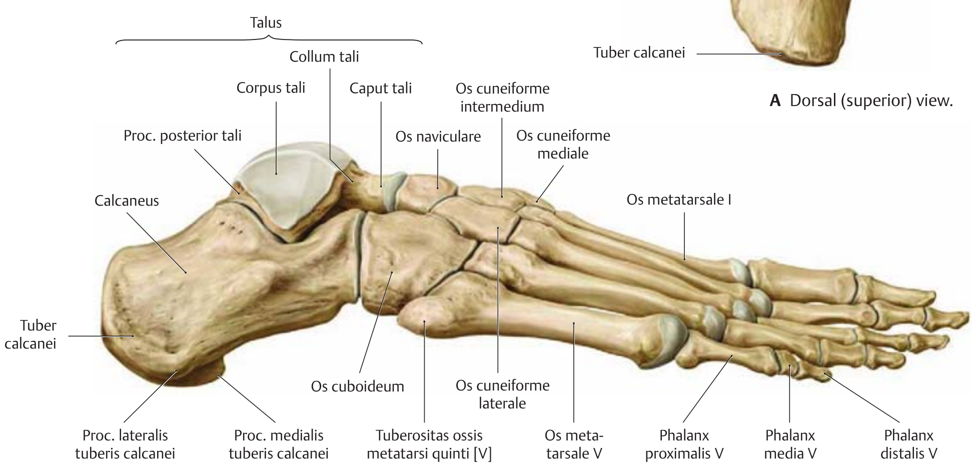


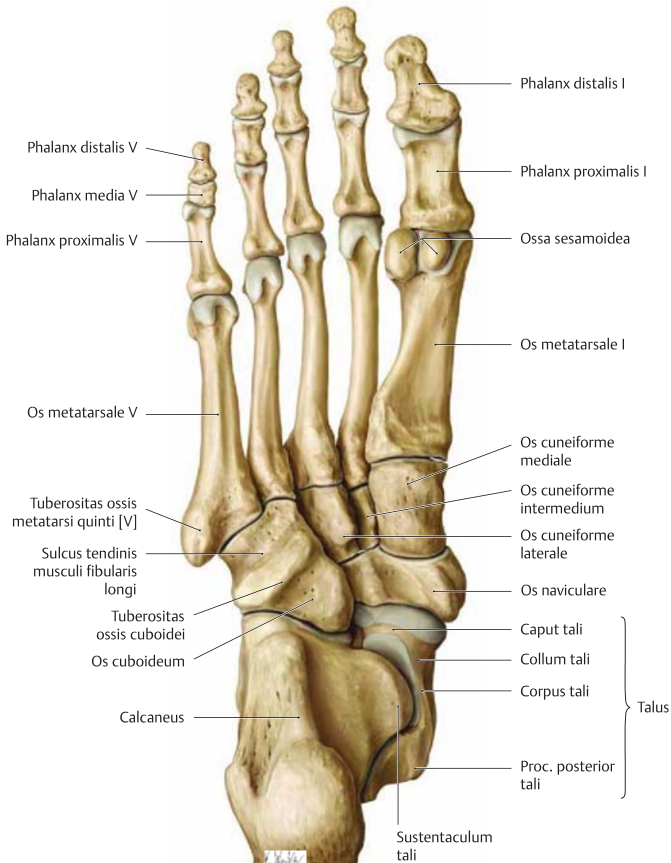
Fig. 26.2 Ossa pedis dexter



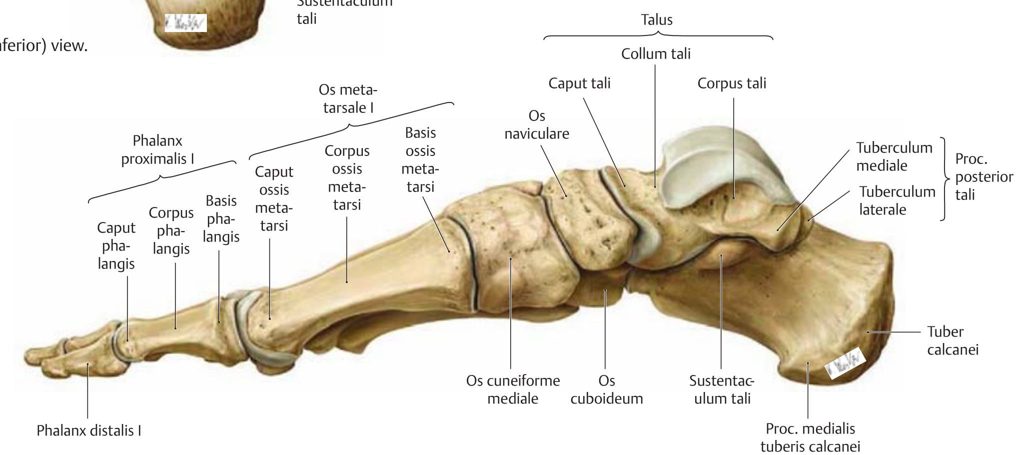
A Dorsal (superior) view.



B Lateral view.



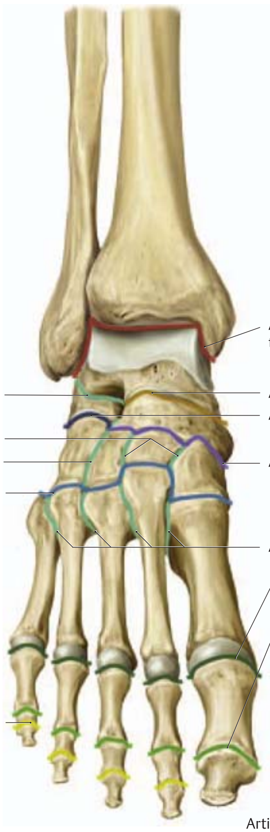
C Plantar (inferior) view.



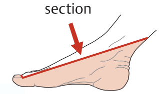
D Medial view.

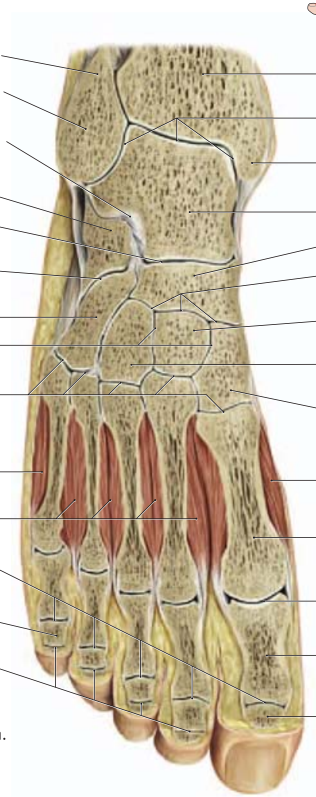
Articulationes Pedis (I)

Fig. 26.3 **Joints of the foot**
Right foot with articulatio talocruralis in plantar flexion.



A Anterior view.

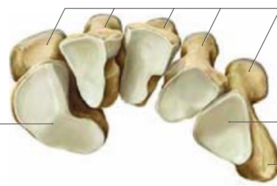




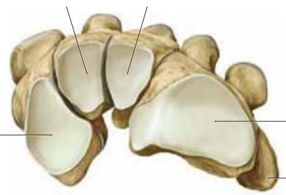
B Superior view of coronal section.

Fig. 26.4 Proximal articular surfaces
Right foot, proximal view.

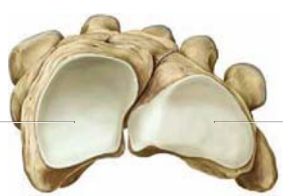
A Articulationes metatarsophalangea.



B Articulationes tarsometatarsales.

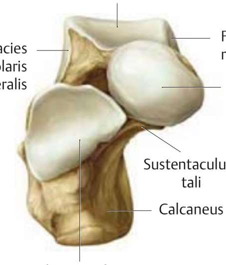


C Articulationes cuneonavicularis and calcaneocuboidea.



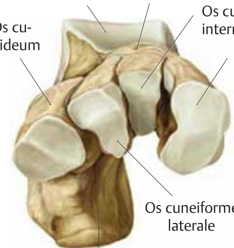
D Articulationes talocalcaneonavicularis and calcaneocuboidea.

Fig. 26.5 Distal articular surfaces
Right foot, distal view.

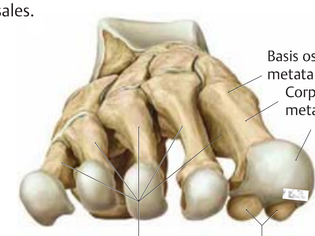


A Articulationes talocalcaneonavicularis and calcaneocuboidea.

B Articulationes cuneonavicularis and calcaneocuboidea.

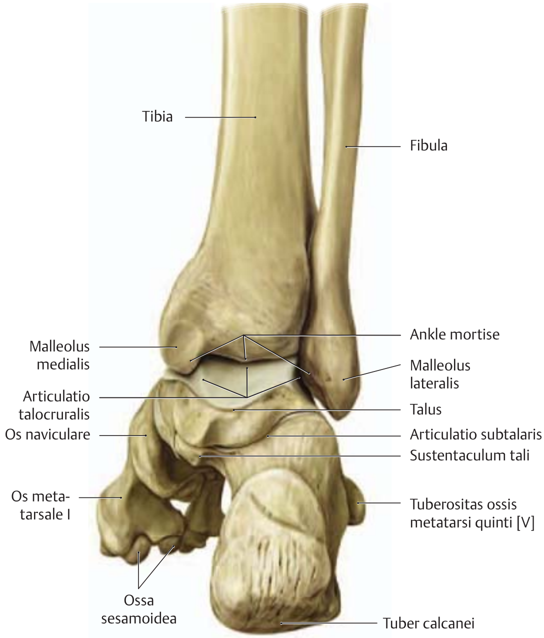


C Articulationes tarsometatarsales.



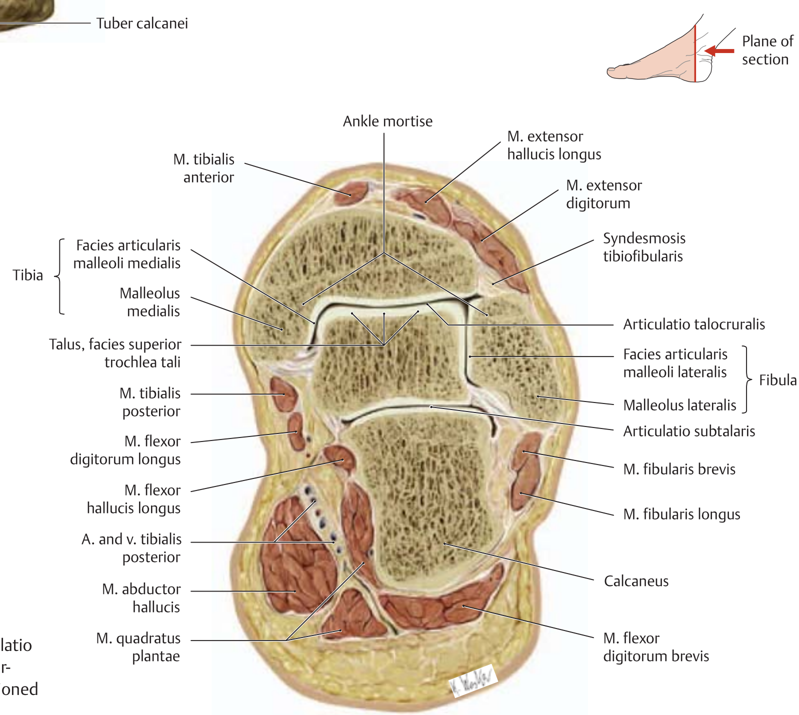
D Articulationes metatarsophalangeae.

Articulationes Pedis (II)



A Posterior view with foot in neutral (0-degree) position.

Fig. 26.6 **Articulationes talocruralis and subtalaris**
Right foot. Articulatio talocruralis (ankle) joint is formed by the distal ends of the tibia and fibula (ankle mortise) articulating with trochlea tali. The articulatio subtalaris joint consists of an anterior and a posterior compartment (the articulatio talocalcaneus and articulatio talocalcaneonavicularis, respectively) divided by the lig. talocalcaneum interosseum (see p. 409).



B Coronal section, proximal view. Articulatio talocruralis is plantar flexed, and the articulatio subtalaris joint has been sectioned through its posterior compartment.

Fig. 26.7 **Articulatio talocruralis and articulatio subtalaris: Sagittal section**
Right foot, medial view.

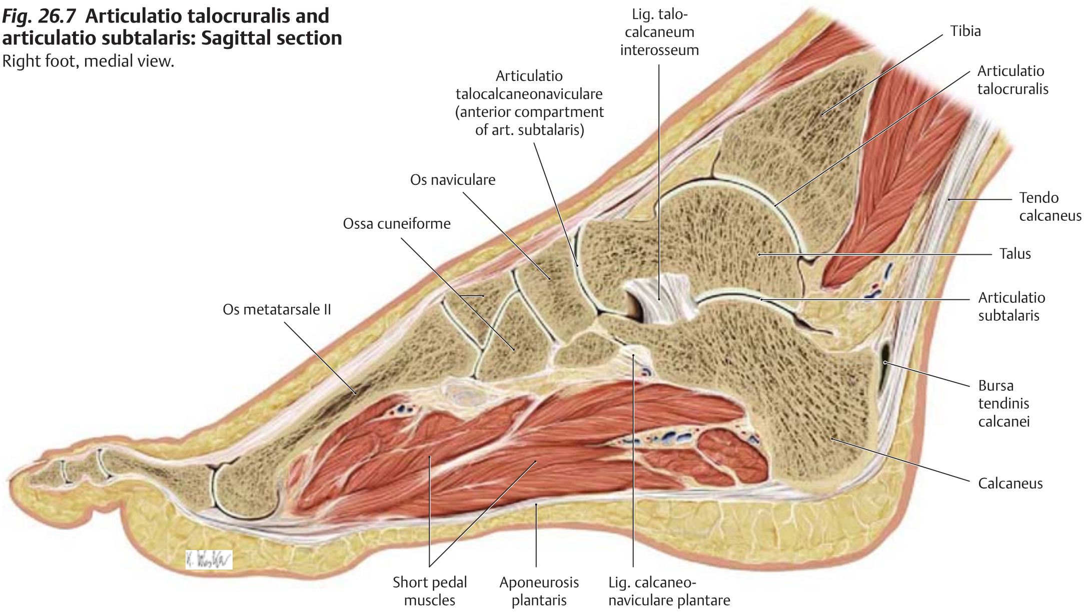
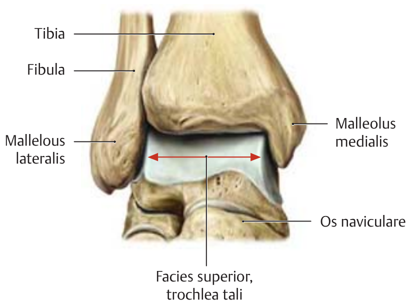
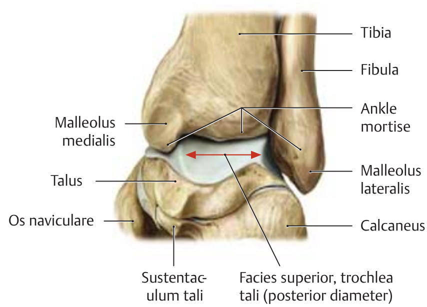


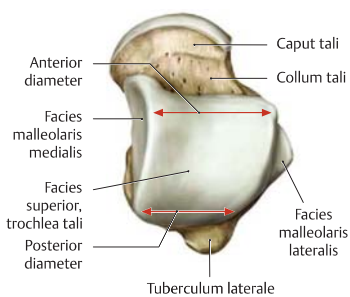
Fig. 26.8 **Articulatio talocruralis**
Right foot.



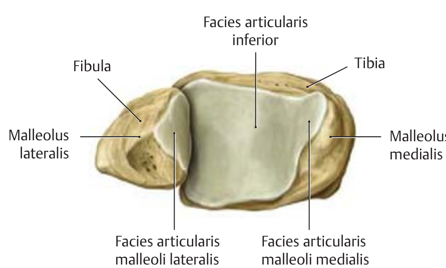
A Anterior view.



B Posterior view.



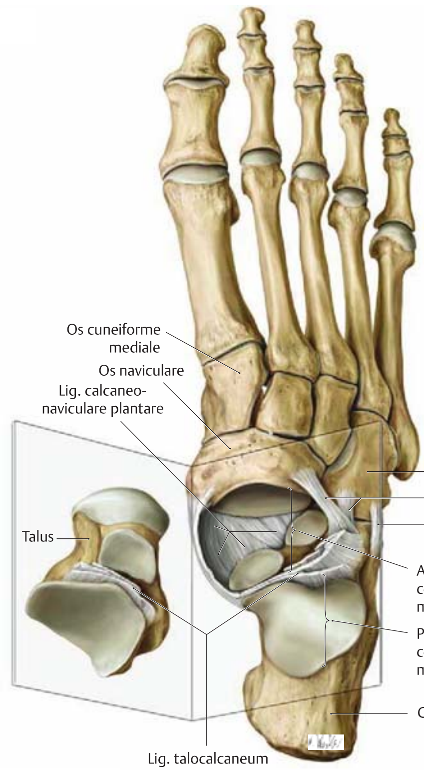
C Proximal (superior) view of talus.



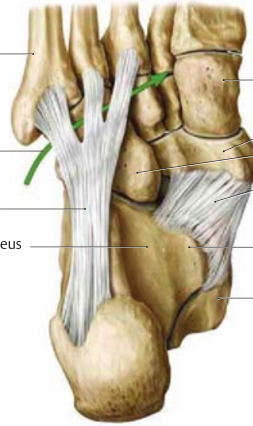
D Distal (inferior) view of ankle mortise.

Articulationes Pedis (III)

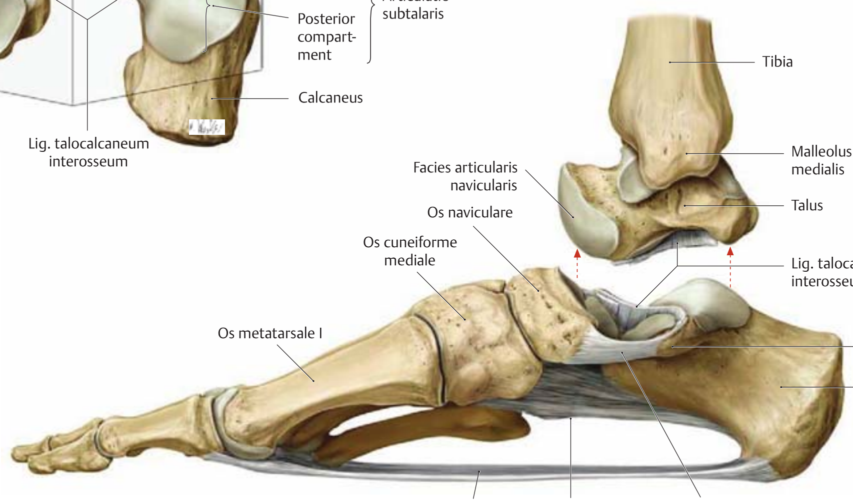
Fig. 26.9 **Articulatio subtalaris and ligaments**
Right foot with opened articulatio subtalaris. The articulatio subtalaris consists of two distinct articulations separated by lig. talocalcaneus interosseum: the posterior compartment (articulatio talocalcaneus) and the anterior compartment (articulatio talocalcaneonavicularis).



A Dorsal view.

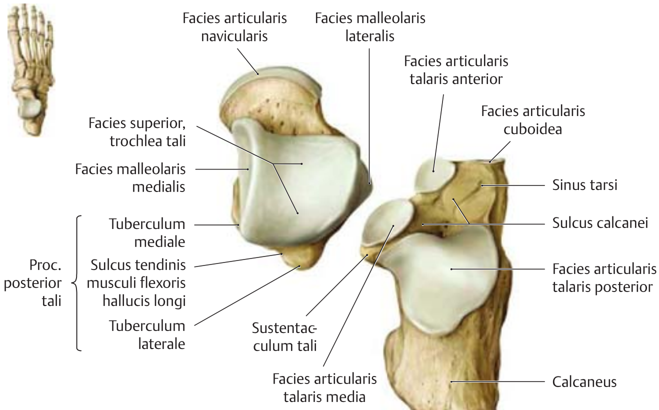


B Plantar view. Lig. calcaneonaviculare plantare ("the spring ligament") completes the bony socket of the articulatio talocalcaneus. Lig. plantare longum converts tuberositas ossis cuboidei into a tunnel for the m. fibularis longus tendon (arrow).

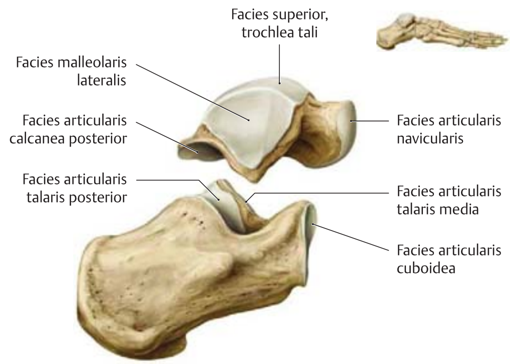


C Medial view. Lig. talocalcaneum interosseum has been divided and the talus displaced upward. Note the course of lig. calcaneonaviculare plantare, which functions with lig. plantare longum and aponeurosis plantaris to support the longitudinal arch of the foot.

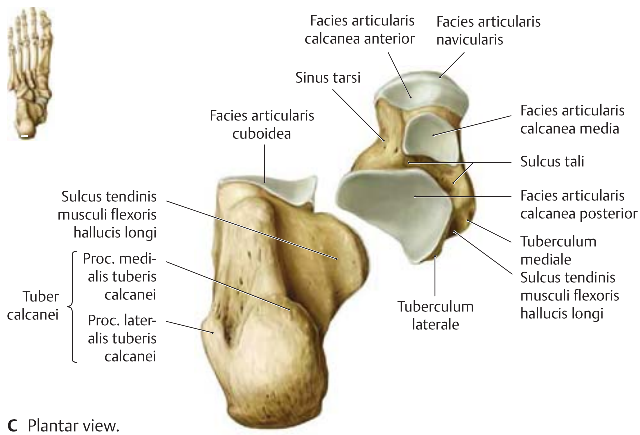
Fig. 26.10 **Talus and calcaneus**
The two tarsal bones have been separated at the art. subtalaris to demonstrate their articular surfaces.



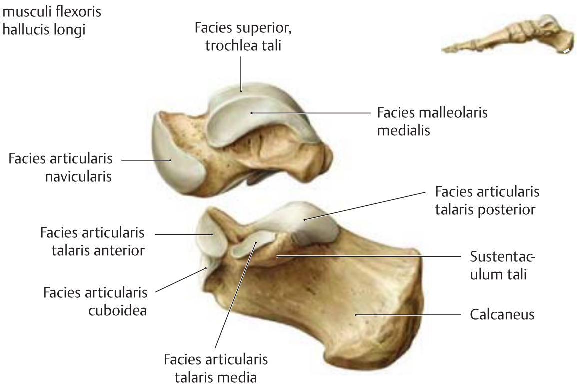
A Dorsal (superior) view.



B Lateral view.



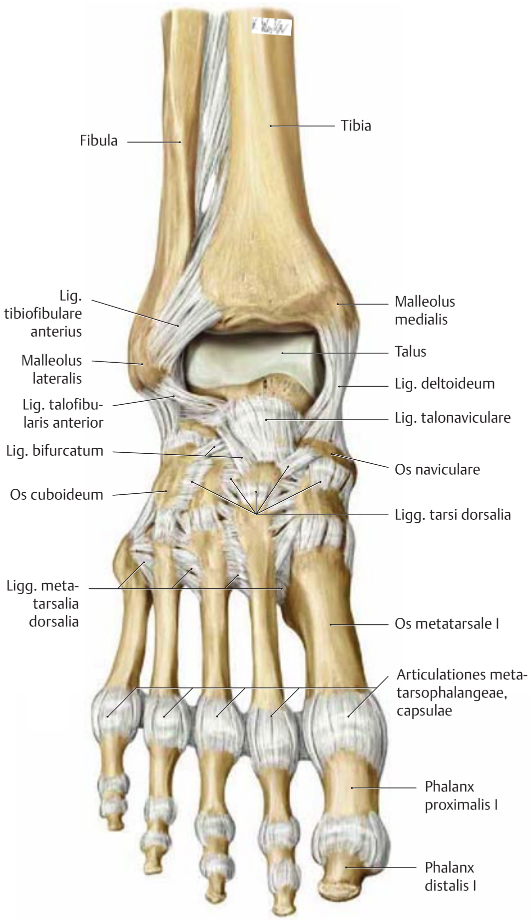
C Plantar view.



D Medial view.

Ligaments of the Ankle & Foot

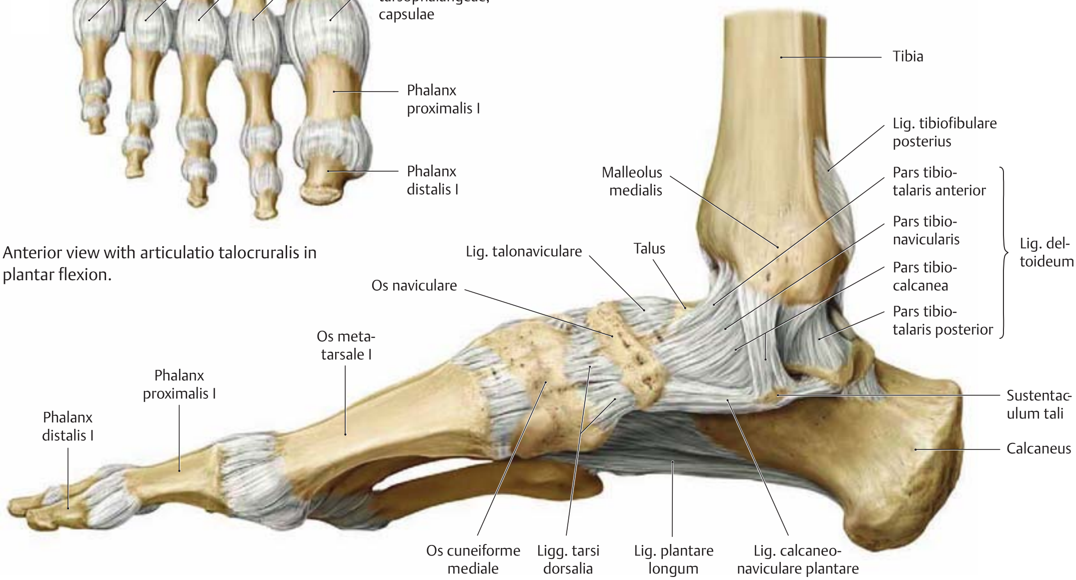
The ligaments of the foot are classified as belonging to the articulatio talocruralis, articulatio subtalaris, metatarsus, forefoot, or sole of the foot. Lig. collaterale mediale and laterale, along with the syndesmotic ligaments, are of major importance in the stabilization of the subtalar joint.



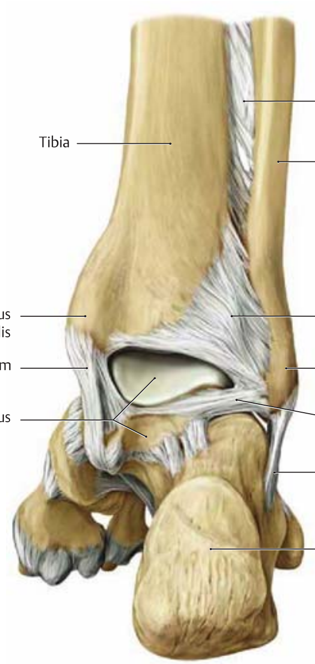
A Anterior view with articulatio talocruralis in plantar flexion.

Fig. 26.11 **Ligaments of the ankle and foot**
Right foot. See p. 406 for inferior view.

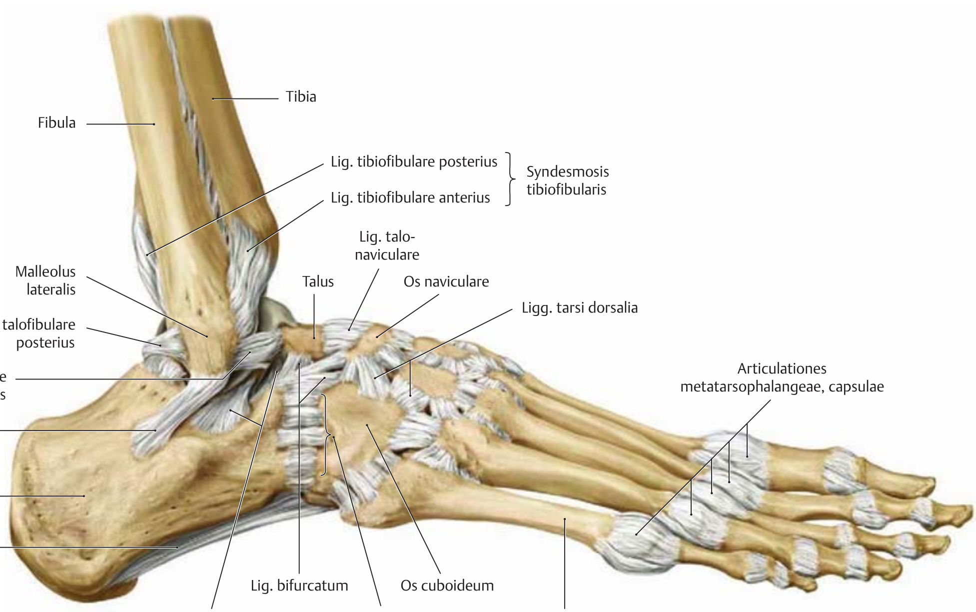
Table 26.1	Ligaments of the talocrural joint	
Lig. collaterale laterale	Lig. talofibulare anterius	
	Lig. talofibulare posterius	
	Lig. calcaneofibulare.	
Lig. collaterale mediale	Lig. deltoideum	Pars tibiotalaris anterior
		Pars tibiotalaris posterior
		Pars tibionavicularis
		Pars tibiocalcanea
Syndesmosis tibiofibularis	Lig. tibiofibulare anterius	
	Lig. tibiofibulare posterius	



B Medial view.



C Posterior view in plantigrade foot position.

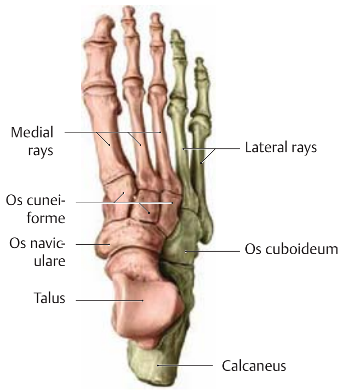


D Lateral view.

Plantar Vault & Arches of the Foot

Fig. 26.12 Plantar vault

Right foot. The forces of the foot are distributed among two lateral (fibular) and three medial (tibial) rays. The arrangement of these rays creates a longitudinal and a transverse arch in the sole of the foot, helping the foot absorb vertical loads.



A Plantar vault, superior view. Lateral rays in green, medial rays in red.

B Pes rectus: Normal plantar arches.

C Pes planus: Loss of longitudinal arch (flat foot).

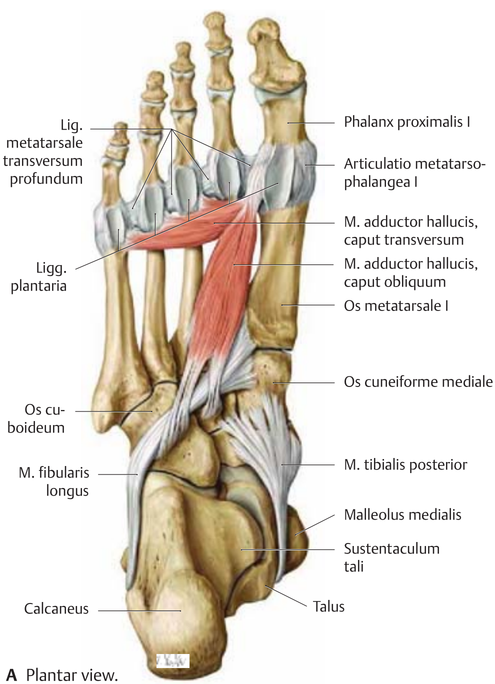
D Pes cavus: Increased height of longitudinal arch.

E Pes transversoplanus: Loss of transverse arch (splayfoot).

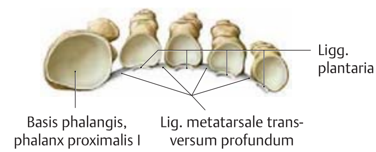
Fig. 26.13 Stabilizers of the transverse arch

Right foot. The transverse pedal arch is supported by both active and passive stabilizing structures (muscles and ligaments, respectively).

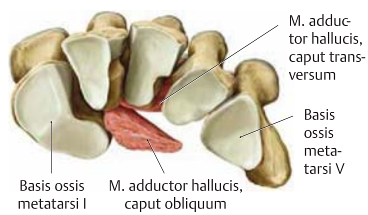
Note: The arch of the forefoot has only passive stabilizers, whereas the arches of the metatarsus and tarsus have only active stabilizers.



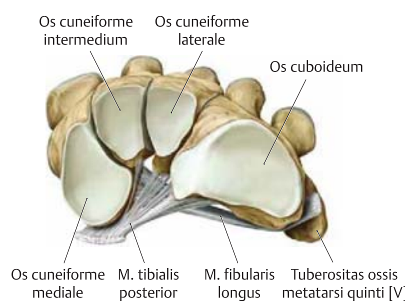
A Plantar view.



B Anterior arch (forefoot), proximal view.

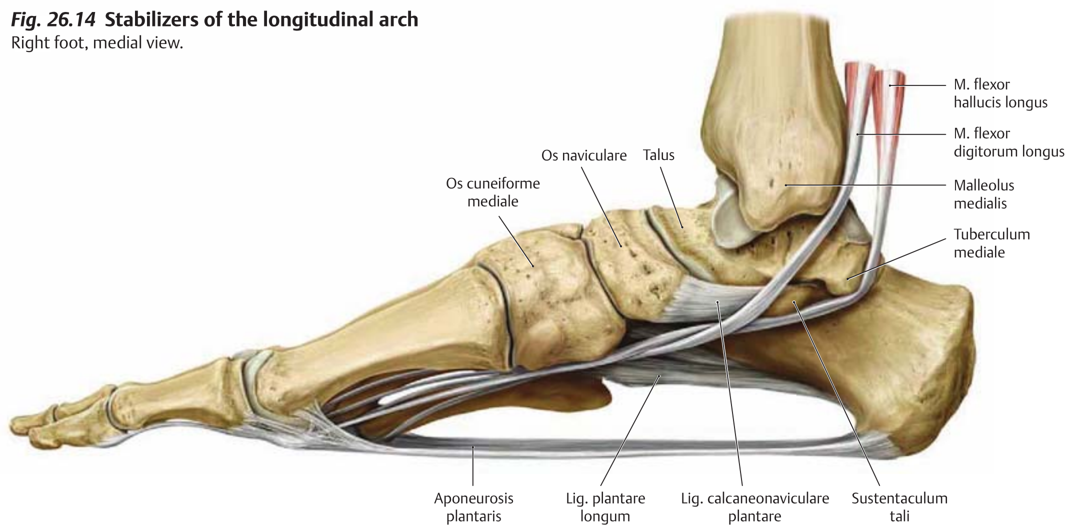


C Metatarsal arch, proximal view.

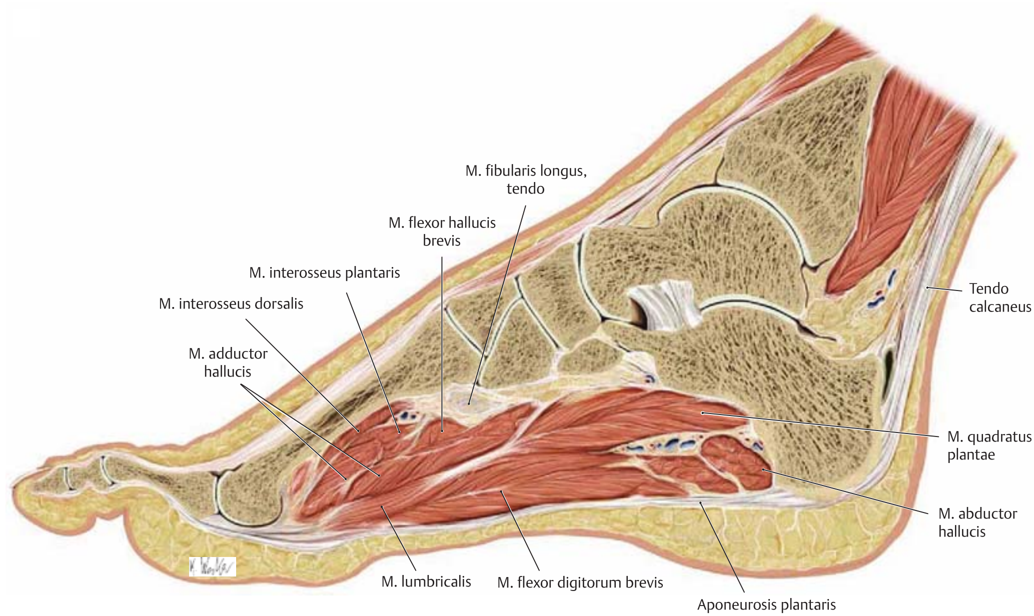


D Tarsal region, proximal view.

***Fig. 26.14* Stabilizers of the longitudinal arch**
Right foot, medial view.



A Passive stabilizers of the longitudinal arch.



B Active stabilizers of the longitudinal arch. Sagittal section at the level of the second ray. The major active stabilizers of the foot are the m. abductor hallucis, m. flexor hallucis brevis, m. flexor digitorum brevis, m. quadratus plantae, and m. abductor digiti minimi.

Muscles of the Sole of the Foot

Fig. 26.15 **Aponeurosis plantaris**
Right foot, plantar view. Aponeurosis plantaris is a tough aponeurotic sheet, thickest at the center, that blends with the dorsal fascia (not shown) at the borders of the foot.

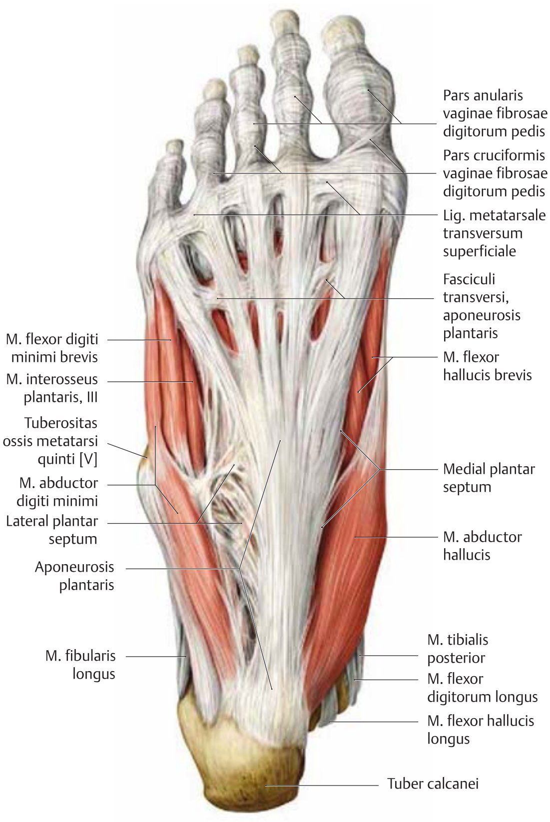
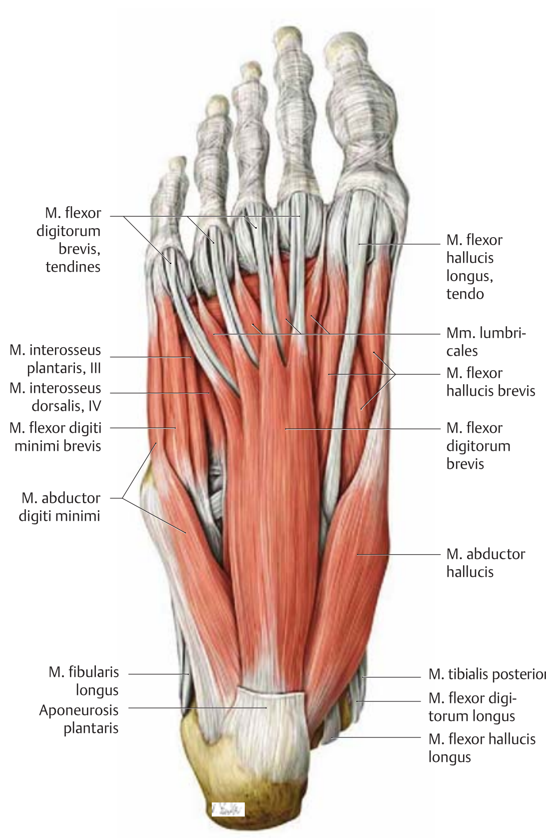
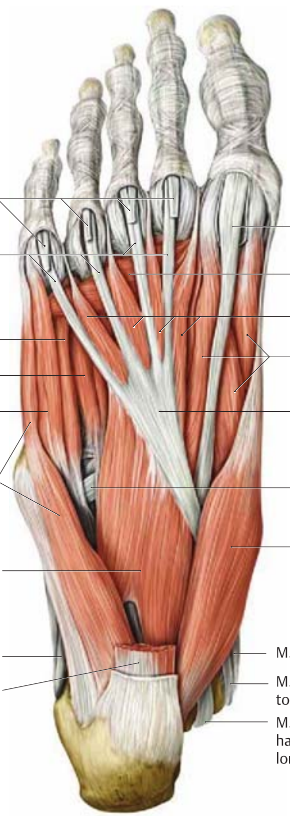


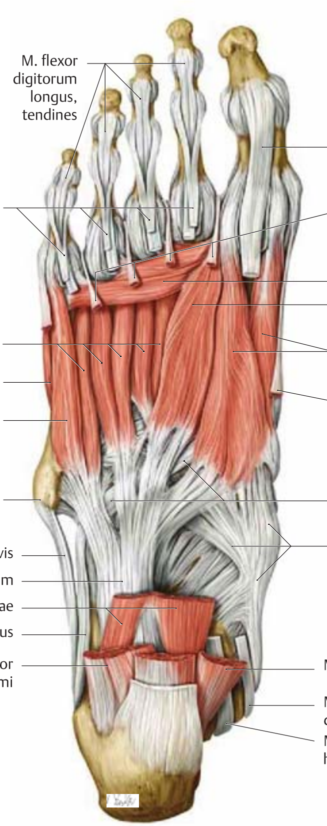
Fig. 26.16 **Intrinsic muscles**
Right foot, plantar view.



A Superficial (first) layer. *Removed:* Aponeurosis plantaris, including lig. metatarsale transversum superficiale.



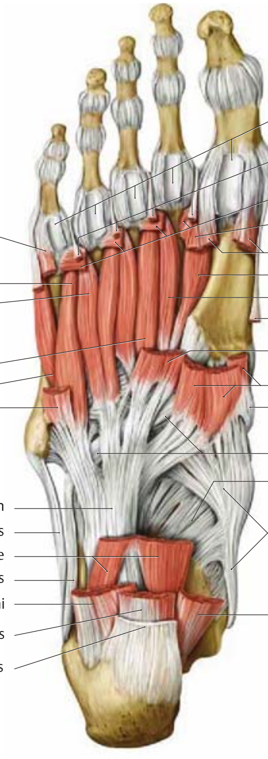
B Second layer. *Removed:* M. flexor digitorum brevis.



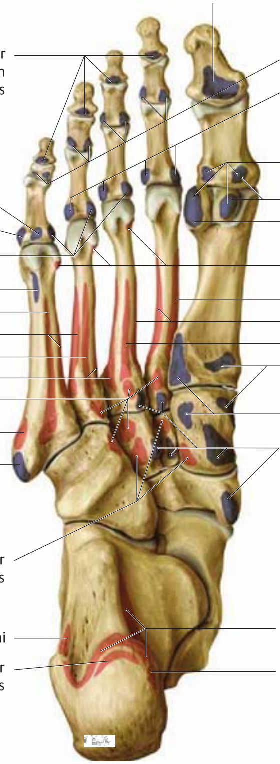
C Third layer. *Removed:* M. abductor digiti minimi, m. abductor hallucis, m. quadratus plantae, m. lumbricales, and tendons of m. flexor digitorum longus and m. hallucis longus.

Muscles & Tendon Sheaths of the Foot

Fig. 26.17 **Deep intrinsic muscles**
Right foot, plantar view.

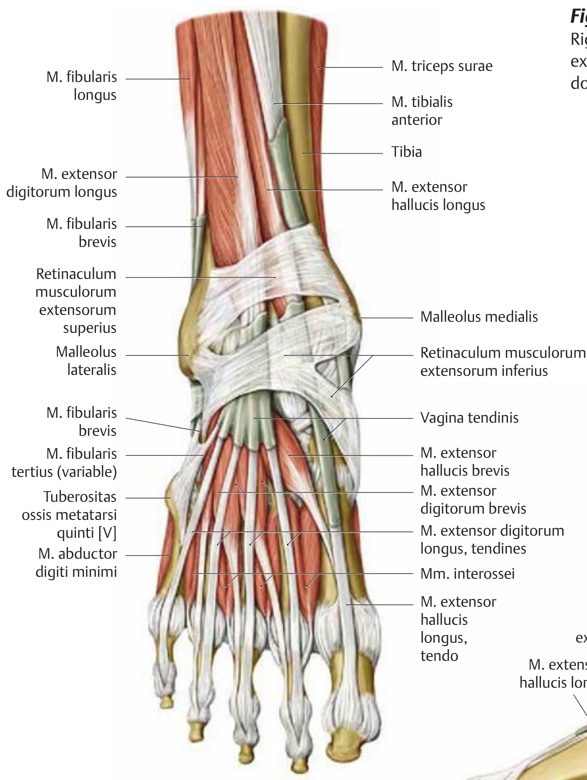


A Fourth layer. *Removed:* M. adductor hallucis, m. flexor digiti minimi brevis, and m. flexor hallucis brevis.

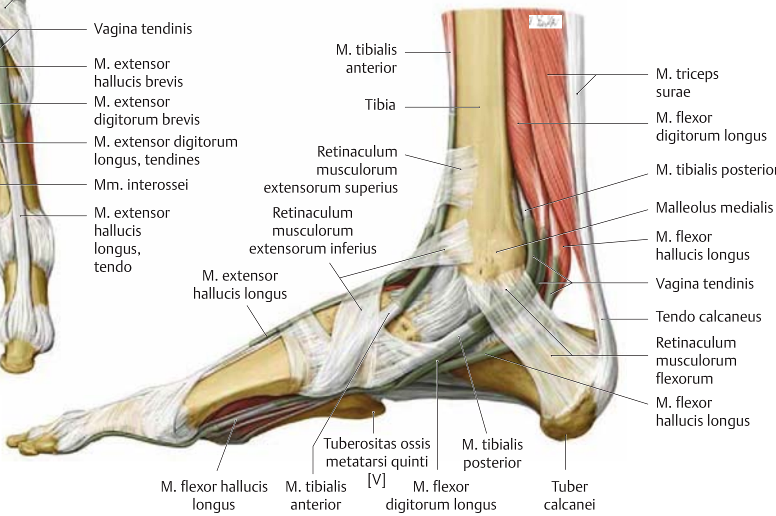


B Muscle origins (red) and insertions (blue) on the foot.

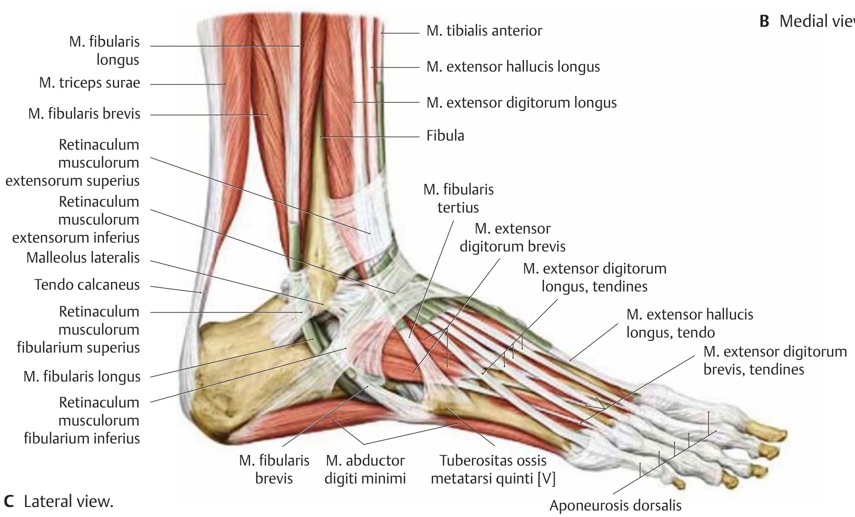
Fig. 26.18 **Tendon sheaths and retinacula of the ankle**
Right foot. The superior and inferior extensor retinacula retain the long extensor tendons, the fibularis retinacula hold the fibular muscle tendons in place, and the flexor retinaculum retains the long flexor tendons.



A Anterior view with articulatio talocruralis in plantar flexion.



B Medial view.

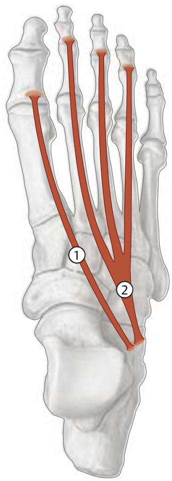


C Lateral view.

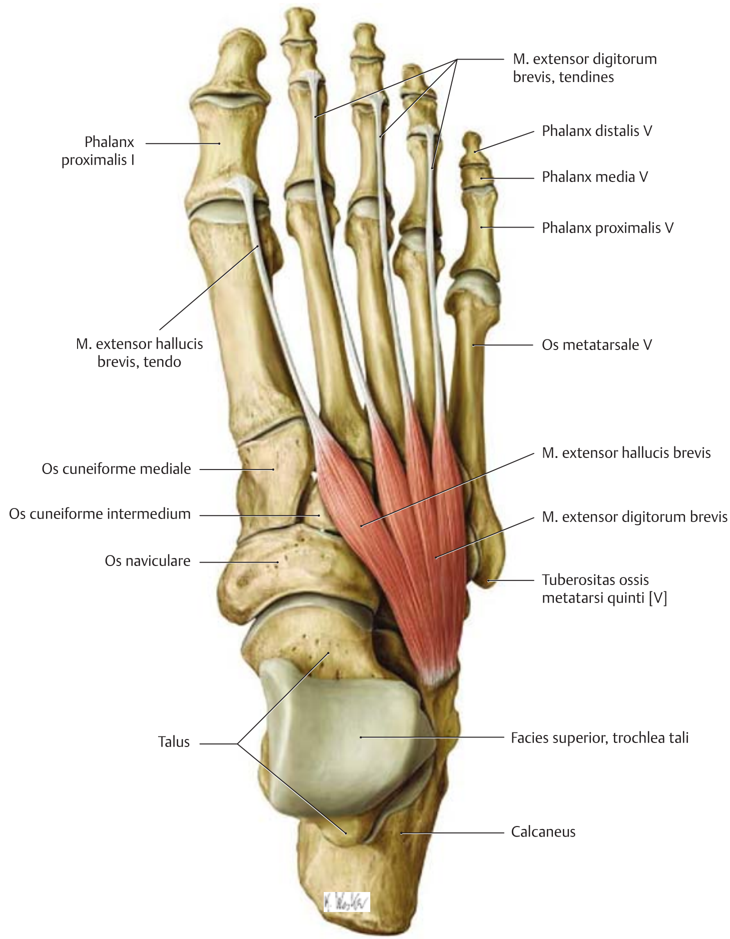
Muscle Facts (I)

The dorsal surface (dorsum) of the foot contains only two muscles, m. extensor digitorum brevis and m. extensor hallucis brevis. The sole of the foot, however, is composed of four complex layers that maintain the arches of the foot.

Fig. 26.19 **Intrinsic muscles of the dorsum**
Right foot, dorsal view.



A Schematic.



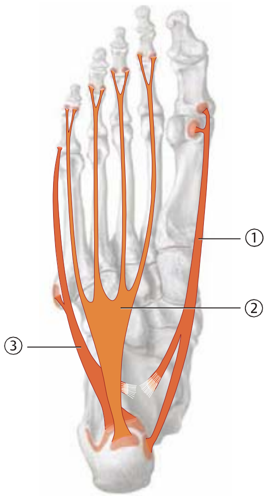
B Dorsal muscles of the foot.

Table 26.2 **Intrinsic muscles of the dorsum**

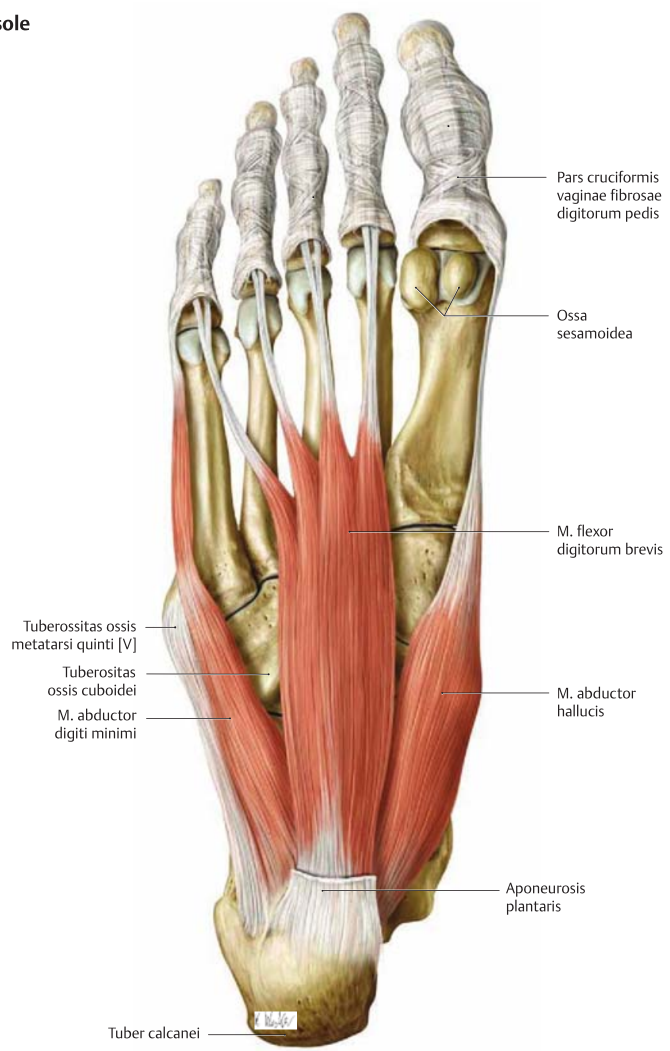
Muscle	Origin	Insertion	Innervation	Action
① M. extensor digitorum brevis	Calcaneus (fascies dorsalis)	2nd to 4th toes (aponeurosis dorsalis and bases of phalanges mediales)	N. fibularis profundus (L5, S1)	Extension of the MTP and PIP joints of the 2nd to 4th toes
② M. extensor hallucis brevis		1st toe (aponeurosis dorsalis and phalanx proximalis)		Extension of the MTP joints of the 1st toe

MTP = Articulationes metatarsophalangeae; PIP = Articulationes interphalangeae proximales.

Fig. 26.20 **Superficial intrinsic muscles of the sole**
Right foot, plantar view.



A First layer (schematic).

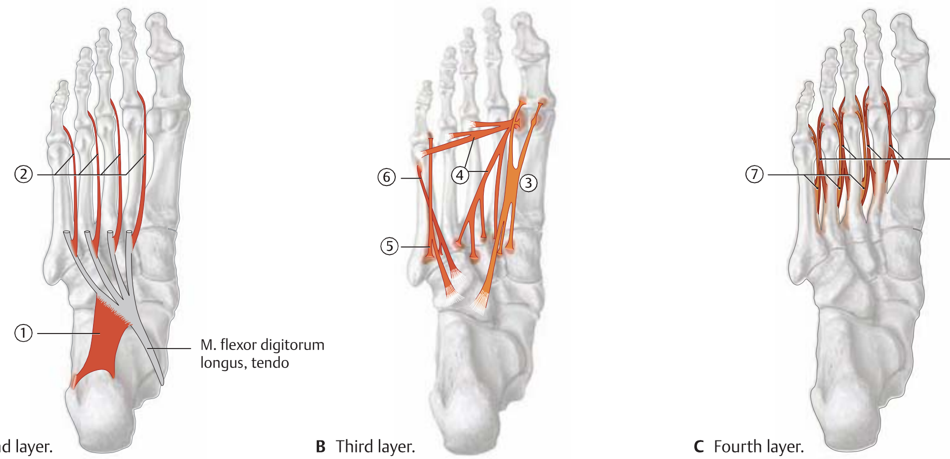


B Intrinsic muscles of the sole, first layer.

Table 26.3	**Superficial intrinsic muscles of the sole**			
Muscle	**Origin**	**Insertion**	**Innervation**	**Action**
① M. abductor hallucis	Tuber calcanei (proc. medialis)	1st toe, basis phalanx proximalis via the medial sesamoid	N. plantaris medialis (S1, S2)	• 1st MTP joint: flexion and abduction of the 1st toe • Supports the longitudinal arch
② M. flexor digitorum brevis	Tuber calcanei, aponeurosis plantaris	2nd to 5th toes, phalanx medialis		• Flexes the MTP and PIP joints of the 2nd to 5th toes • Supports the longitudinal arch
③ M. abductor digiti minimi		5th toe (basis phalanx proximalis, tuberositas ossis metatarsi V)	N. plantaris lateralis (S1–S3)	• Flexes the MTP joint of the 5th toe • Abducts the 5th toe • Supports the longitudinal arch
MTP = Articulationes metatarsophalangeae; PIP = Articulationes interphalangeae proximales.				

Muscle Facts (II)

Fig. 26.21 **Deep intrinsic muscles of the sole**
Right foot, plantar view.



A Second layer. **B** Third layer. **C** Fourth layer.

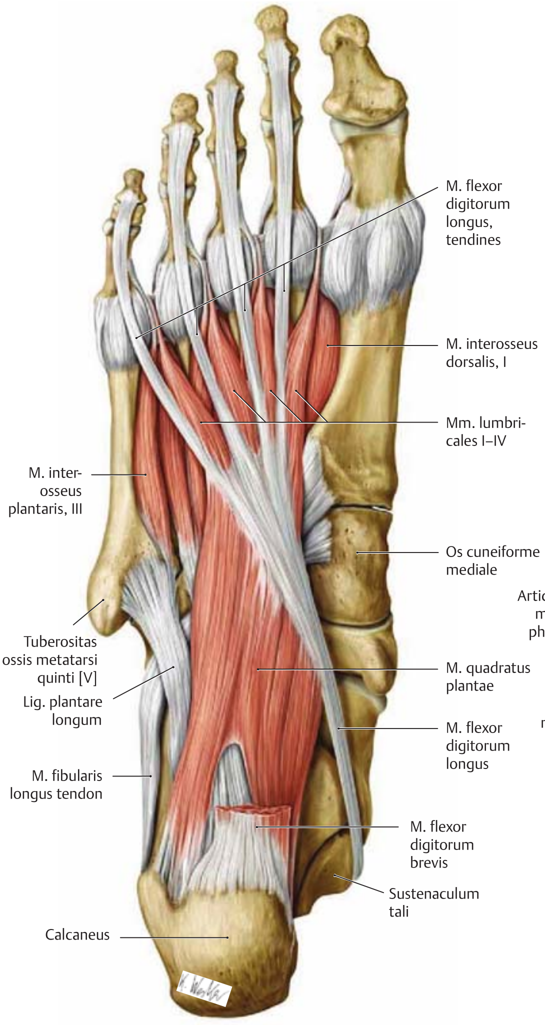
Table 26.4 **Deep intrinsic muscles of the sole**

Muscle	Origin	Insertion	Innervation	Action
① M. quadratus plantae	Tuber calcanei (medial and plantar borders on plantar side)	M. flexor digitorum longus tendon (lateral border)	N. plantaris lateralis (S1–S3)	Redirects and augments the pull of m. flexor digitorum longus
② Mm. lumbricales pedis I–IV	M. flexor digitorum longus tendons (medial borders)	2nd to 5th toes (at aponeurosis dorsalis)	M. lumbricalis I: n. plantaris medialis (S2, S3) Mm. lumbricales II–IV: n. plantaris lateralis (S2, S3)	• Flexes the MTP joints of 2nd to 5th toes • Extension of IP joints of 2nd to 5th toes • Adducts 2nd to 5th toes toward the big toe
③ M. flexor hallucis brevis	Os cuboideum, os cuneiforme laterale and lig. calcaneocuboideum plantare	1st toe (at base of phalanx proximales via medial and lateral sesamoids)	Caput mediale: n. plantaris medialis (S1, S2) Caput laterale: n. plantaris lateralis (S1, S2)	• Flexes the first MTP joint • Supports the longitudinal arch
④ M. adductor hallucis	Caput obliquum: Ossa metatarsi II–IV (at bases) Caput transversum: MTPs of 3rd to 5th toes, lig. metatarsale transversum profundum	1st phalanx proximales (at base, by a common tendon via the lateral sesamoid)	N. plantaris lateralis, r. profundus (S2, S3)	• Flexes the first MTP joint • Adducts big toe • Caput transversum: supports transverse arch • Caput obliquum: supports longitudinal arch
⑤ M. flexor digiti minimi brevis	Os metatarsi V (base), lig. plantare longum	5th toe (base of phalanx proximales)	N. plantaris lateralis, r. superficialis (S2, S3)	Flexes the MTP joint of the little toe
⑥ M. opponens digiti minimi*	Lig. plantare longum; m. fibularis longus (at plantar tendon sheath)	Os metatarsale V		Pulls 5th metatarsal in plantar and medial direction
⑦ Mm. interossei plantares I–III	Ossa metatarsi III–V (margo mediales)	3rd to 5th toes (medial base of phalanx proximales)	N. plantaris lateralis (S2, S3)	• Flexes the MTP joints of 3rd to 5th toes • Extension of IP joints of 3rd to 5th toes • Adducts 3rd to 5th toes toward 2nd toe
⑧ Mm. interossei dorsales pedis I–IV	Ossa metatarsi I–V (by two heads on opposing sides)	M. interosseus I: phalanx proximales II (medial base) 2nd to 4th mm. interossei: 2nd to 4th phalangis proximales (lateral base), 2nd to 4th toes (at aponeurosis dorsalis)		• Flexes the MTP joints of 2nd to 4th toes • Extension of IP joints of 2nd to 4th toes • Abducts 3rd and 4th toes from 2nd toe

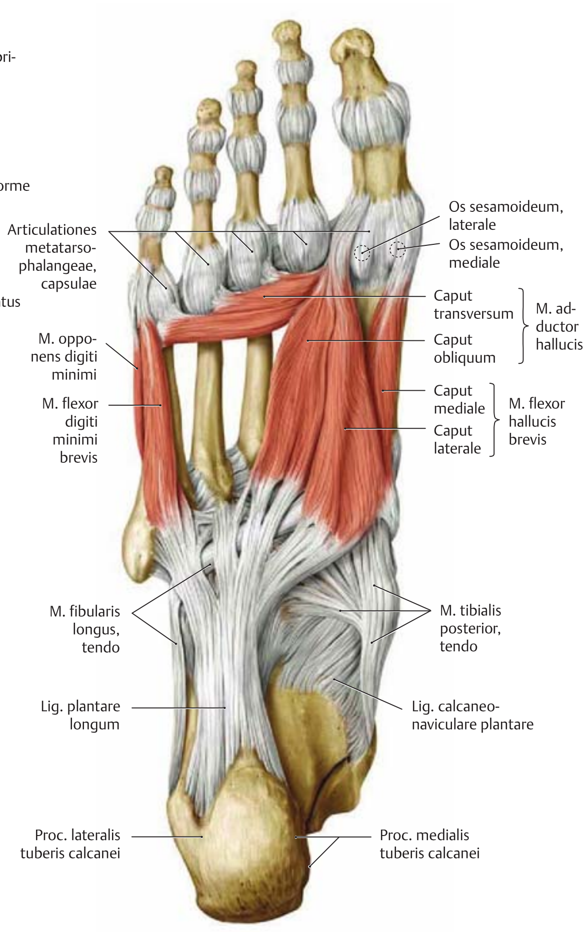
IP = Articulationes interphalangeae pedis; MTP = Articulationes metatarsophalangeae. *May be absent.

Fig. 26.22 Deep intrinsic muscles of the sole

Right foot, plantar view.



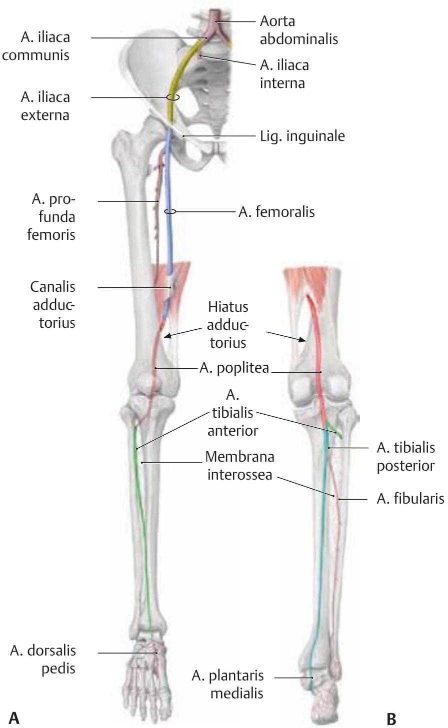
A Intrinsic muscles of the sole, second and fourth layers.

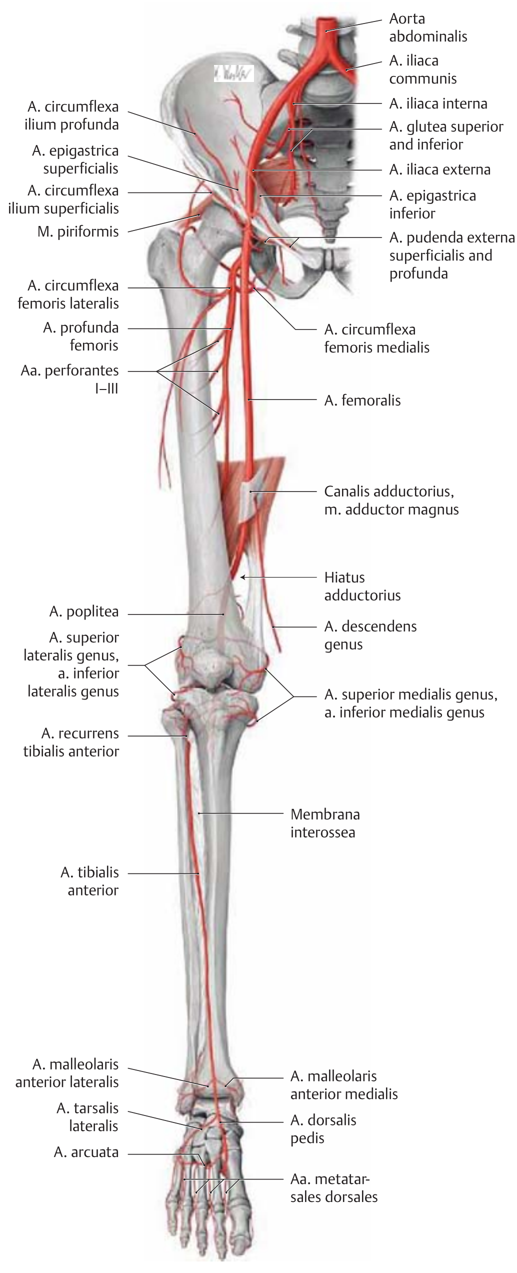


B Intrinsic muscles of the sole, third layer.

Arteries of the Lower Limb

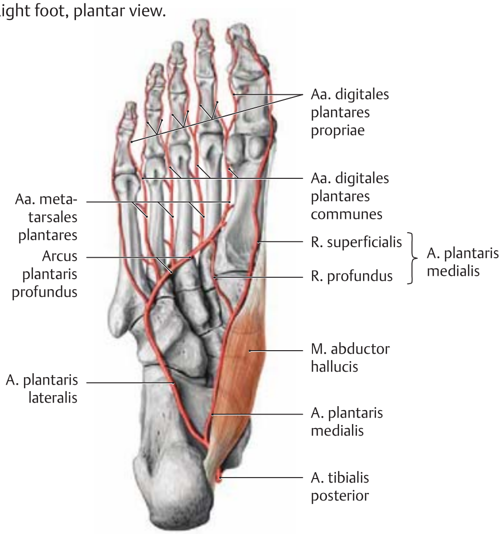
Fig. 27.1 **Arteries of the lower limb**
Right limb, anterior (**A**) and posterior (**B**) views.





C Course of the arteries, anterior view.

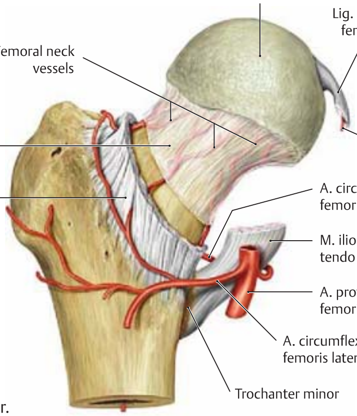
Fig. 27.2 **Arteries of the sole of the foot**
Right foot, plantar view.



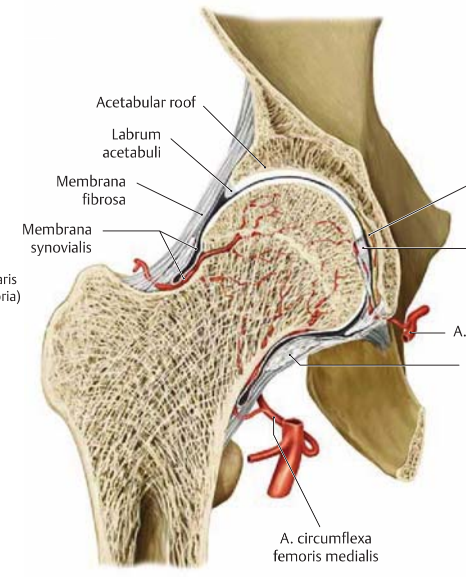
> **Clinical**
>
> **Necrosis of caput femoris**
>
> Dislocation or fracture of caput femoris (e.g., in patients with osteoporosis) may disrupt the anastomoses between r. acetabularis and the femoral neck vessels, resulting in femoral head necrosis.

Fig. 27.3 Arteries of caput femoris

Right art. coxae, anterior view.



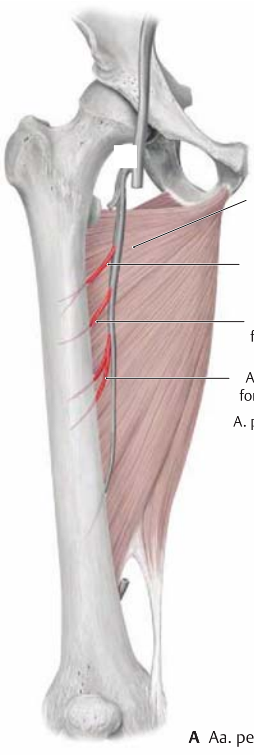
A Right femur.



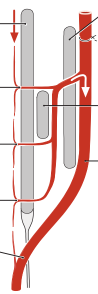
B Coronal section.

Fig. 27.4 Arteries of the thigh and leg

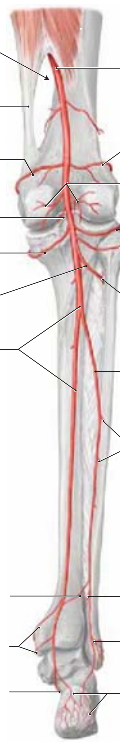
Right leg.



A Aa. perforantes, posterior view.



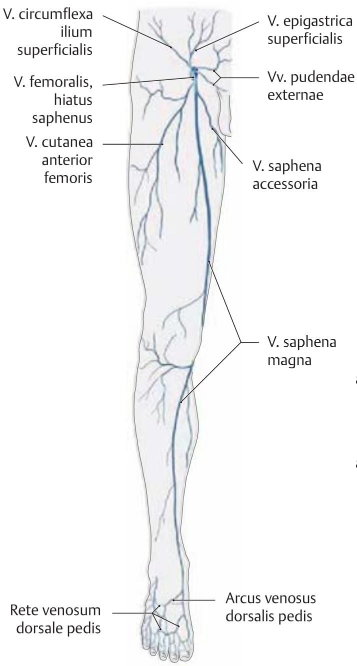
B Longitudinal section.



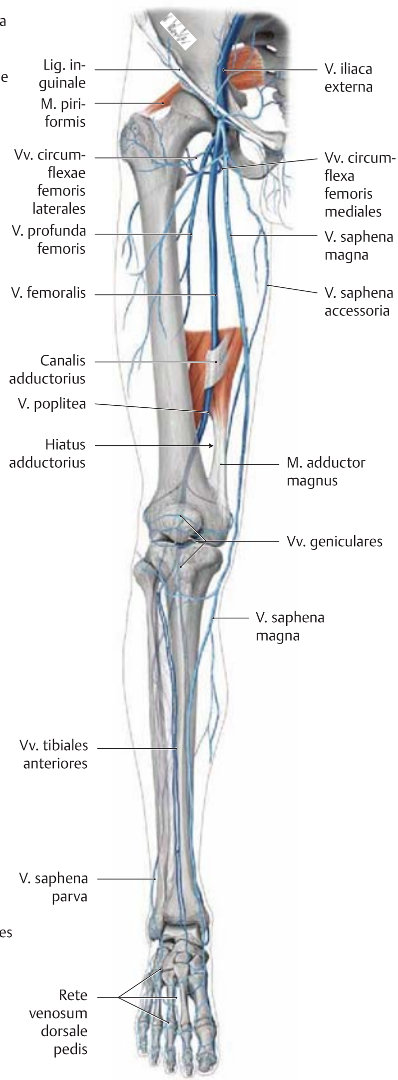
C Arteries of the posterior leg.

Veins & Lymphatics of the Lower Limb

***Fig. 27.5* Veins of the lower limb**
Right limb, anterior view.



A Superficial (epifascial) veins.



B Deep veins.

***Fig. 27.6* Veins of the sole of the foot**
Right foot, plantar view.

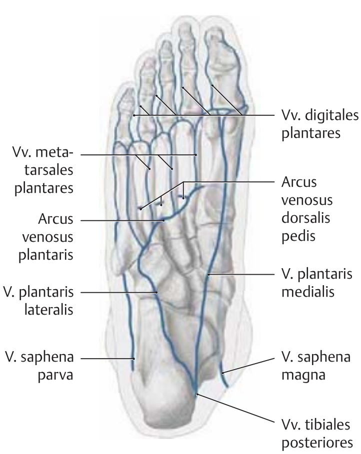
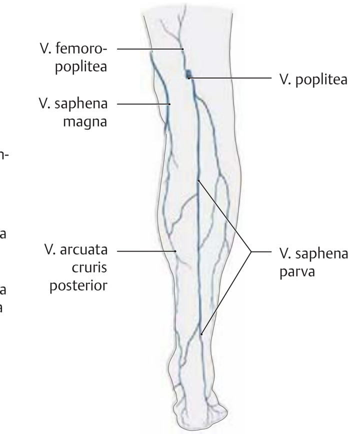
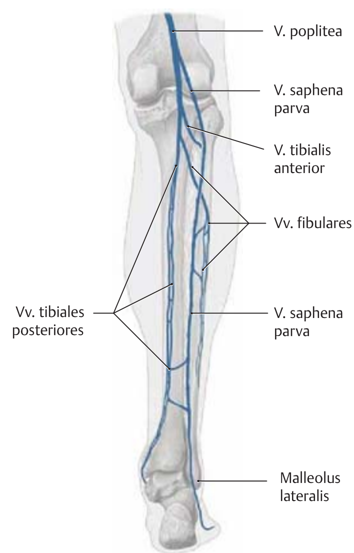


***Fig. 27.7* Veins of the leg**
Right leg, posterior view.



A Superficial (epifascial) veins.



B Deep veins.

***Fig. 27.8* Clinically important perforating veins**
Right leg, medial view.

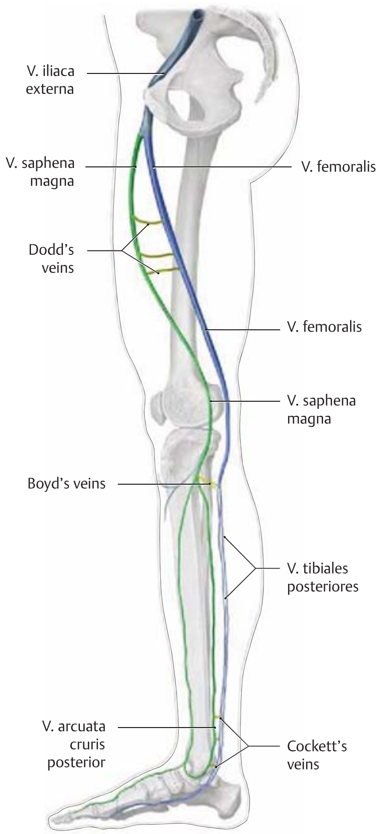
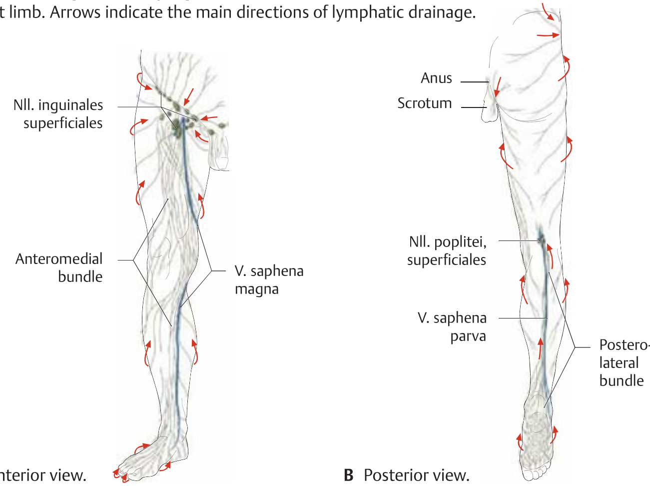


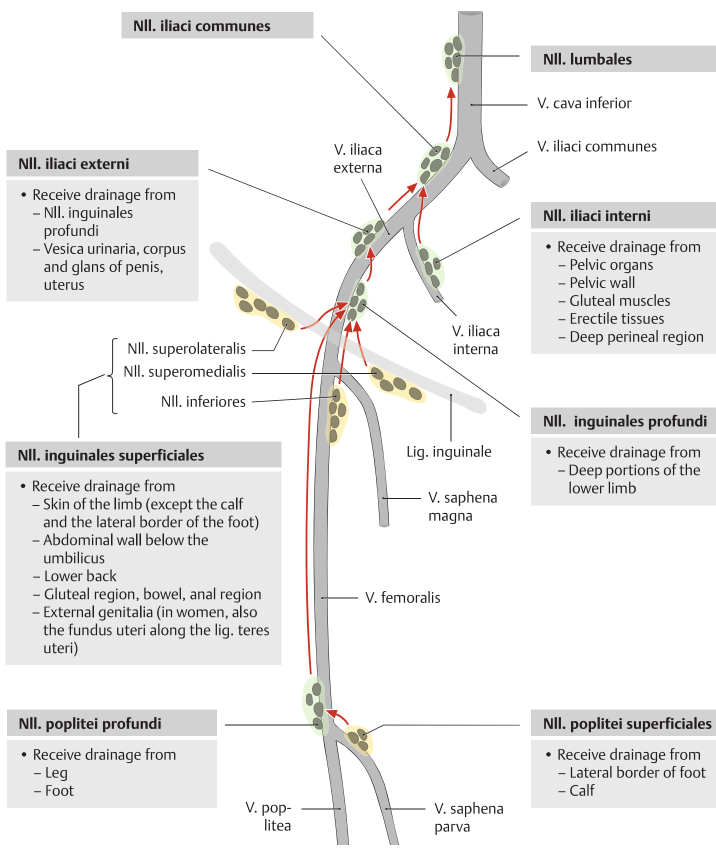
***Fig. 27.9* Superficial lymphatics**
Right limb. Arrows indicate the main directions of lymphatic drainage.



A Anterior view.

B Posterior view.

***Fig. 27.10* Nodus lymphaticus and drainage**
Right limb, anterior view.



Plexus Lumbosacralis

Plexus lumbosacralis supplies sensory and motor innervation to the lower limb. It is formed by the rr. anteriores of nn. lumbales and sacrales, with contributions from the n. subcostalis (T12) and n. coccygeus (Co).

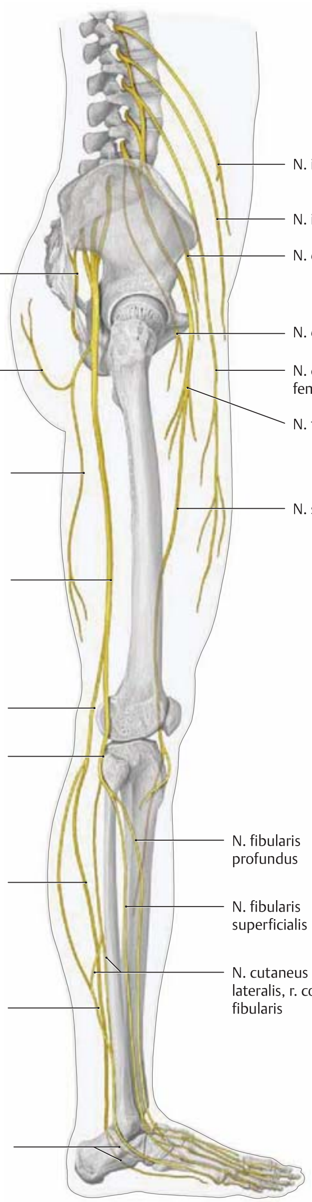
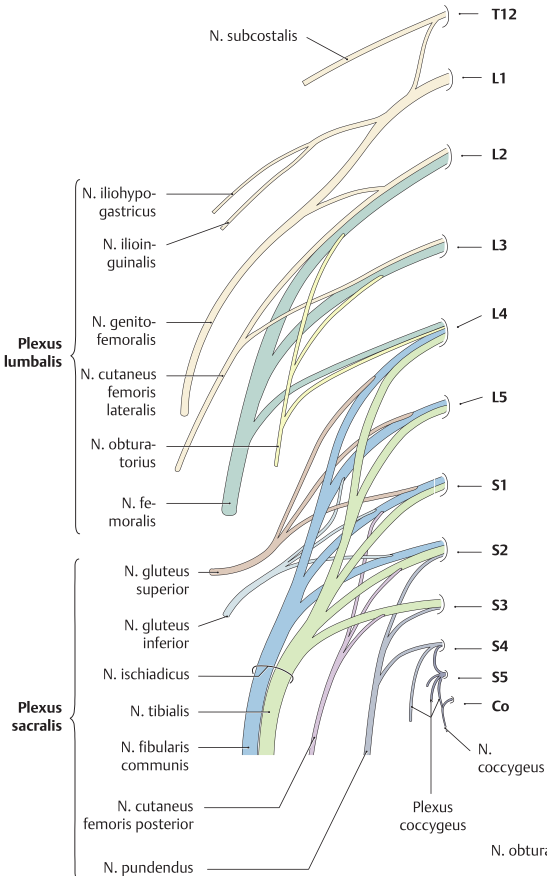


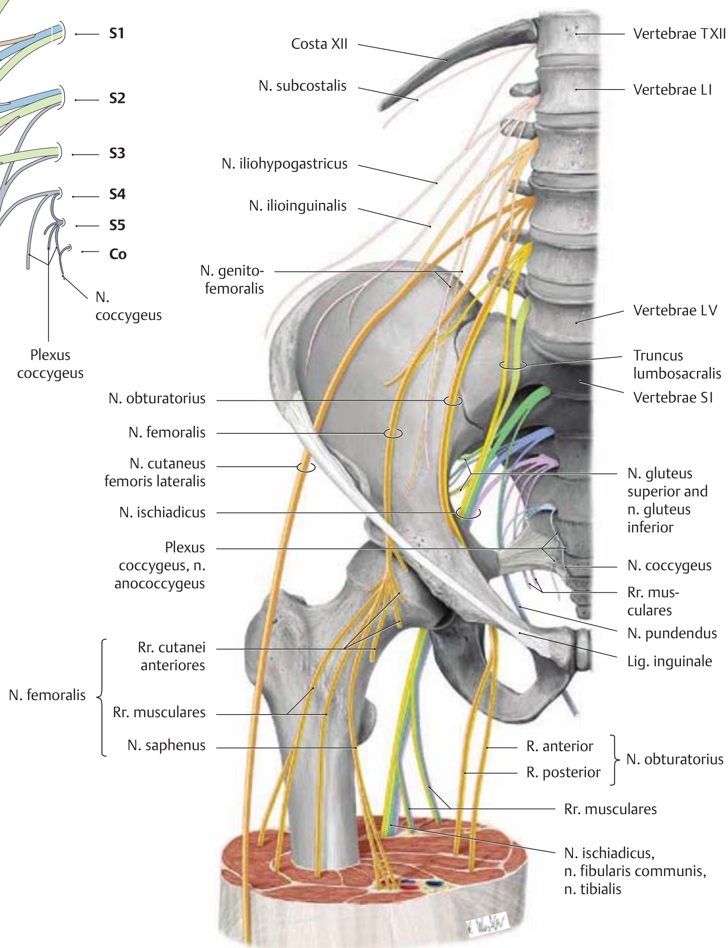
Table 27.1 Nerves of the lumbosacral plexus

Plexus lumbalis			
N. iliohypogastricus		L1	p. 427
N. ilioinguinalis			
N. genitofemoralis		L1–L2	
N. cutaneus femoralis lateralis		L2–L3	
N. obturatorius		L2–L4	p. 428
N. femoralis			p. 429
Plexus sacralis			
N. gluteus superior		L4–S1	p. 431
N. gluteus inferior		L5–S2	
N. cutaneus femoris posterior		S1–S3	p. 430
N. ischiadicus	N. fibularis communis	L4–S2	p. 432
	N. tibialis	L4–S3	p. 433
N. pudendus		S2–S4	pp. 194, 202

Fig. 27.11 **Plexuslumbosacralis**
Right side, anterior view.



A Structure of plexus lumbosacralis.



B Course of plexus lumbosacralis.

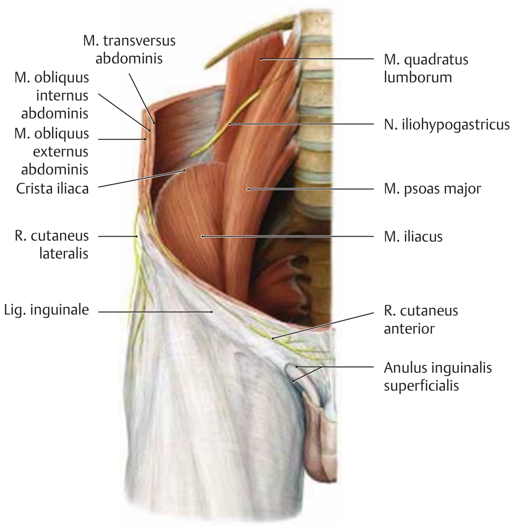
Nerves of Plexus Lumbalis

Table 27.2 Nerves of the lumbar plexus

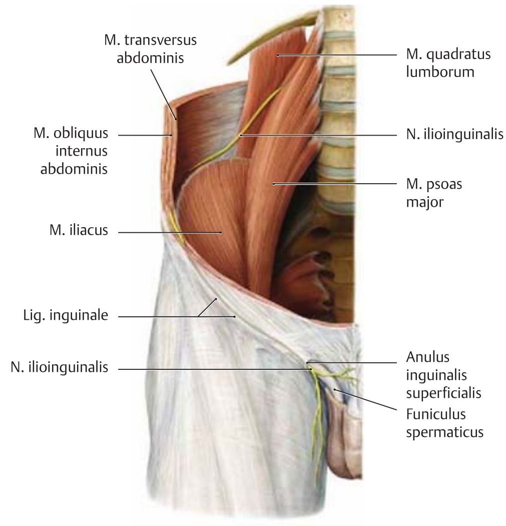
Nerve	Level	Innervated muscle	Cutaneous branches
N. iliohypogastricus	T12–L1	M. transversus abdominis and m. obliquus internus abdominis (inferior portions)	R. cutaneus lateralis, r.cutaneus anterior
N. ilioinguinalis	L1		Male: Nn. scrotales anteriores Female: Nn. labiales anteriores
N. genitofemoralis	L1–L2	Male: M.cremaster (r. genitalis)	R. genitalis R. femoralis
N. cutaneus femoralis lateralis	L2–L3	—	N. cutaneus femoralis lateralis
N. obturatorius	L2–L4	See p. 428	
N. femoralis	L2–L4	See p. 429	
Short, direct muscular branches	T12–L4	M. psoas major M. quadratus lumborum M. iliacus Mm. intertransversarii lumborum	—

Fig. 27.12 **Sensory innervation of the inguinal region**
Right male inguinal region, anterior view.

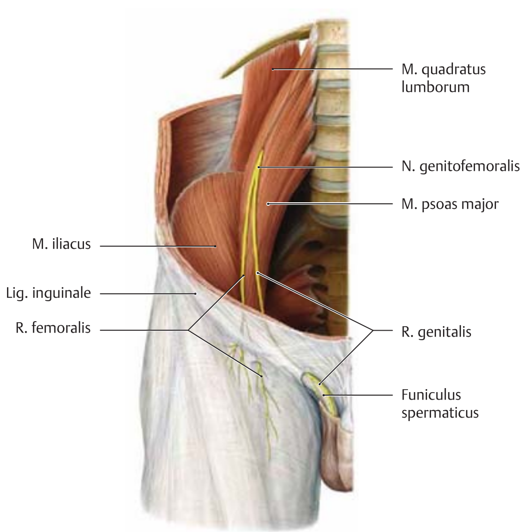
Fig. 27.13 **Nerves of plexus lumbalis**
Right side, anterior view with the anterior abdominal wall removed.



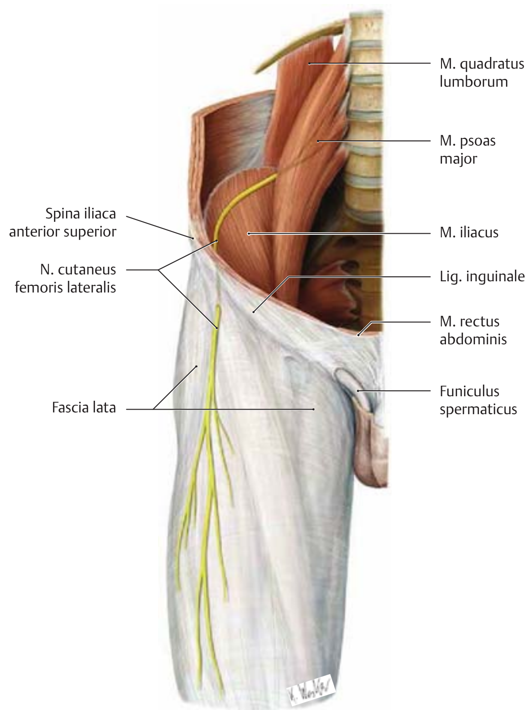
A N. iliohypogastricus.



B N. ilioinguinalis.



C N. genitofemoralis.



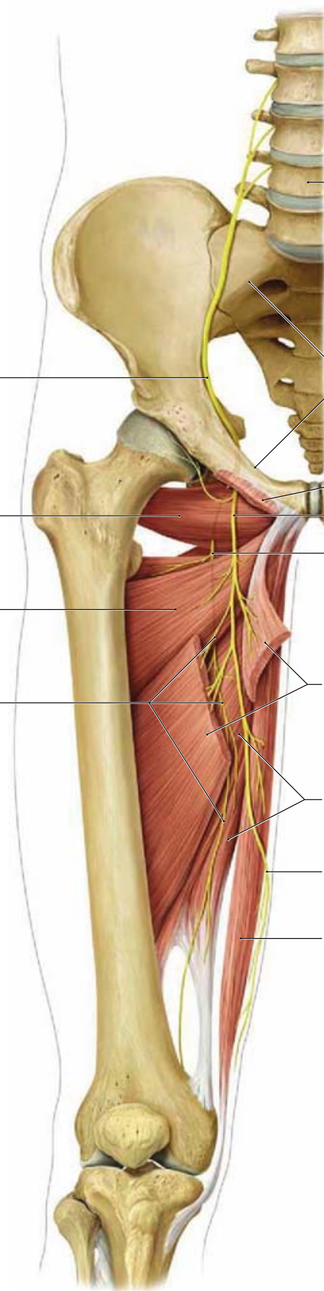
D N. cutaneus femoris lateralis.

Nerves of Plexus Lumbalis: N. Obturatoris & N. Femoralis

Fig. 27.14 **N. obturatorius: Sensory distribution**
Right leg, medial view.

Table 27.3	**N. obturatorius (L2–L4)**
Motor branches	**Innervated muscles**
Direct branch	M. obturatorius externus
R. anterior	M. adductor longus
	M. adductor brevis
	M. gracilis
	M. pectineus
R. posterior	M adductor magnus
Sensory branches	
R. cutaneus	

Fig. 27.15 **N. obturatorius**
Right side, anterior view.



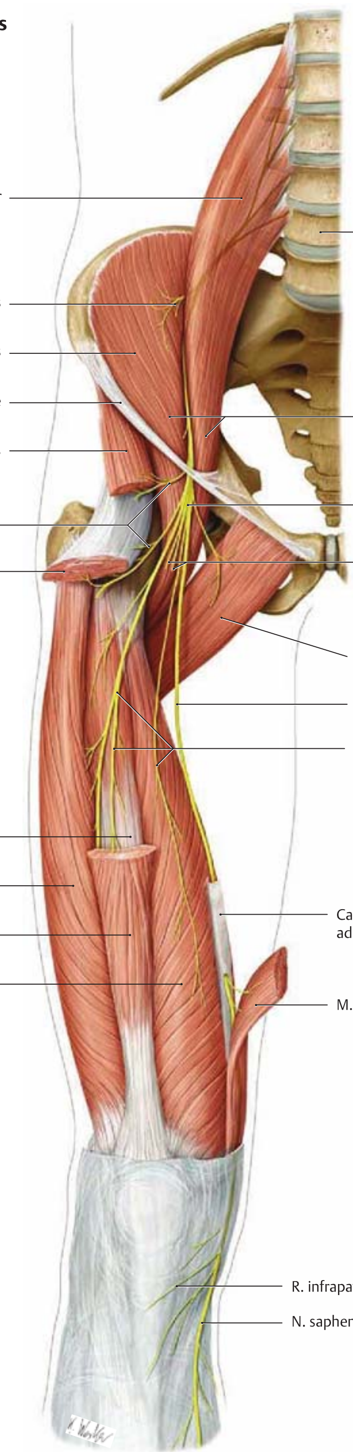


Fig. 27.16 **N. femoralis**
Right side, anterior view.

Fig. 27.17 **N. femoralis: Sensory distribution**
Right limb, anterior view.

Table 27.4	**N. femoralis (L2–L4)**
Motor branches	**Innervated muscles**
Rr. musculares	M. iliopsoas
	M. pectineus
	M. sartorius
	M. quadriceps femoris
Sensory branches	
Rr. cutanei anteriores	
N. saphenus	

Nerves of Plexus Sacralis

Table 27.5 Nerves of plexus sacralis

Nerve		Level	Innervated muscle	Cutaneous branches	
N. gluteus superior		L4–S1	M. gluteus medius M. gluteus minimus M. tensor fasciae latae	—	
N. gluteus inferior		L5–S2	M. gluteus maximus	—	
N. cutaneus femoris lateralis		S1–S3	—	N. cutaneus femoris posterior	Nn. clunium inferiores
					Rr. perineales
Direct branches	N. musculi piriformis	S1–S2	M. piriformis	—	
	N. musculi obturatorii interni	L5–S1	M. obturatorius internus Mm. gemelli	—	
	N. musculi quadrati femoris		M. quadratus femoris	—	
N. ischiadicus	N. fibularis communis	L4–S2	See p. 432		
	N. tibialis	L4–S3	See p. 433		

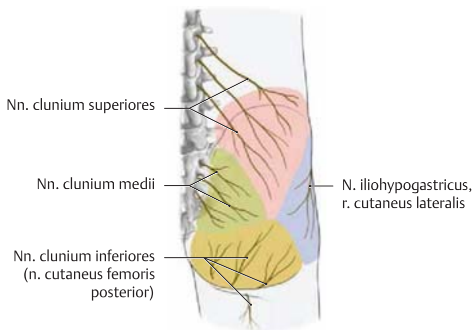


Fig. 27.18 **Sensory innervation of the gluteal region**
Right limb, posterior view.

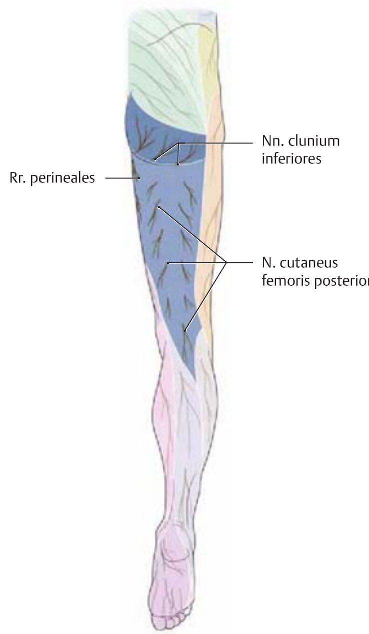


Fig. 27.19 **N. cutaneus femoris posterior: Sensory distribution**
Right limb, posterior view.

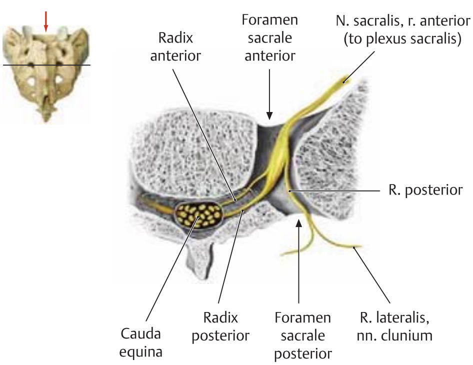
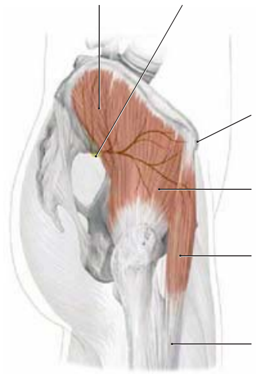
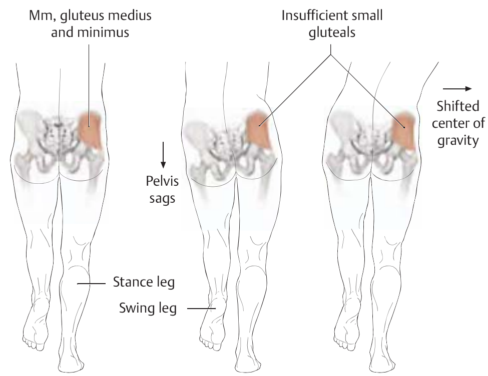


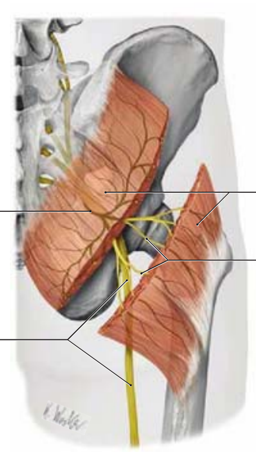
Fig. 27.20 **Emerging n. sacralis**
Horizontal section, superior view.

Fig. 27.21 **Nerves of plexus sacralis**
Right limb.

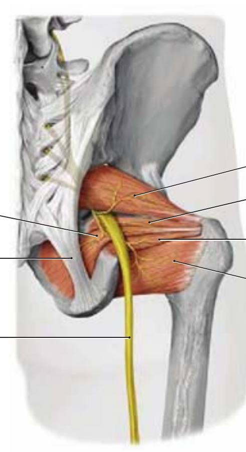


A N. gluteus superior. Lateral view.

> **Clinical**
>
> **Small gluteal muscle weakness**
> The small gluteal muscles on the stance side stabilize the pelvis in the coronal plane. Weakness or paralysis of the small gluteal muscles from damage to the n. gluteus superior (e.g., due to a faulty intramuscular injection) is manifested by weak abduction of the affected hip joint. In a positive Trendelenburg's test, the pelvis sags toward the normal, unsupported side. Tilting the upper body toward the affected side shifts the center of gravity onto the stance side, thereby elevating the pelvis on the swing side (Duchenne's limp). With bilateral loss of the small gluteals, the patient exhibits a typical waddling gait.
>
> 
>
>
> **A** Normal gait. **B** Small gluteal muscle weakness. **C** Duchenne's limp.



B N. gluteus inferior. Posterior view.

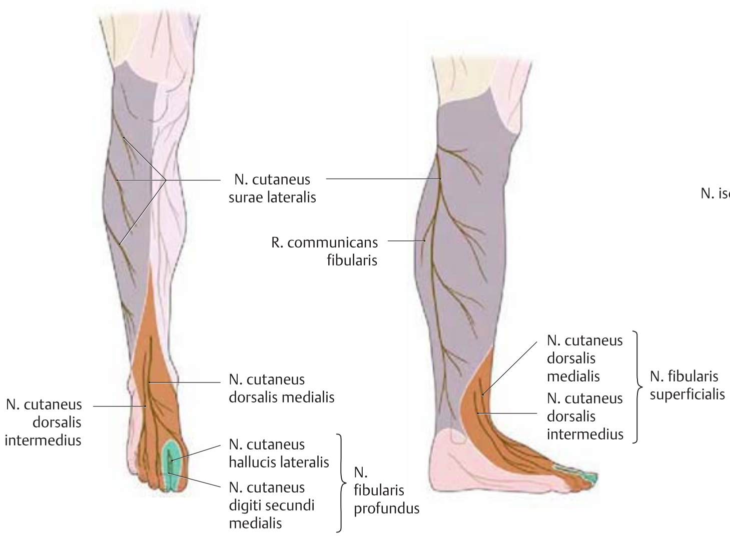


C Direct branches. Posterior view.

Nerves of Plexus Sacralis: N. Ischiadicus

N. ischiadicus gives off several direct muscular branches before dividing into the n. tibialis and n. fibularis communis proximal to the fossa poplitea.

Fig. 27.22 **N. fibularis communis: Sensory distribution**



A Right leg, anterior view.

B Right leg, lateral view.

Fig. 27.23 **N. fibularis communis**
Right limb, lateral view.

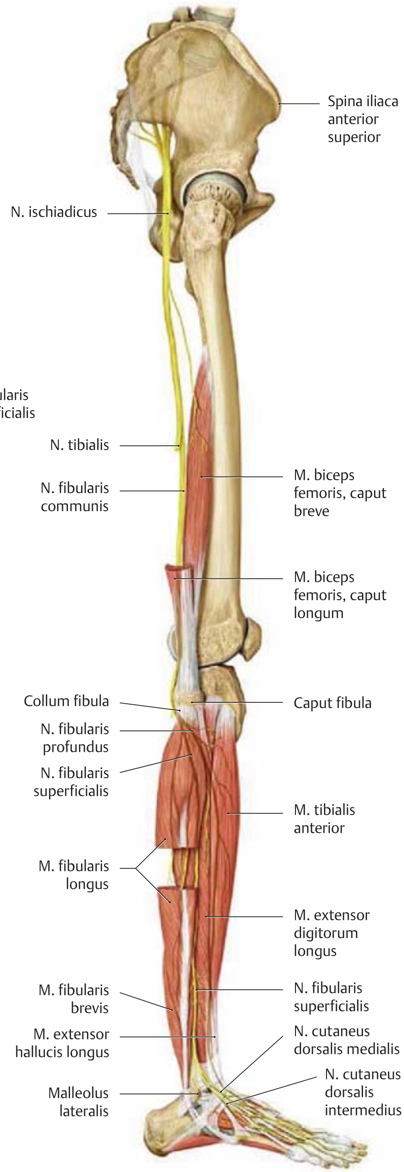
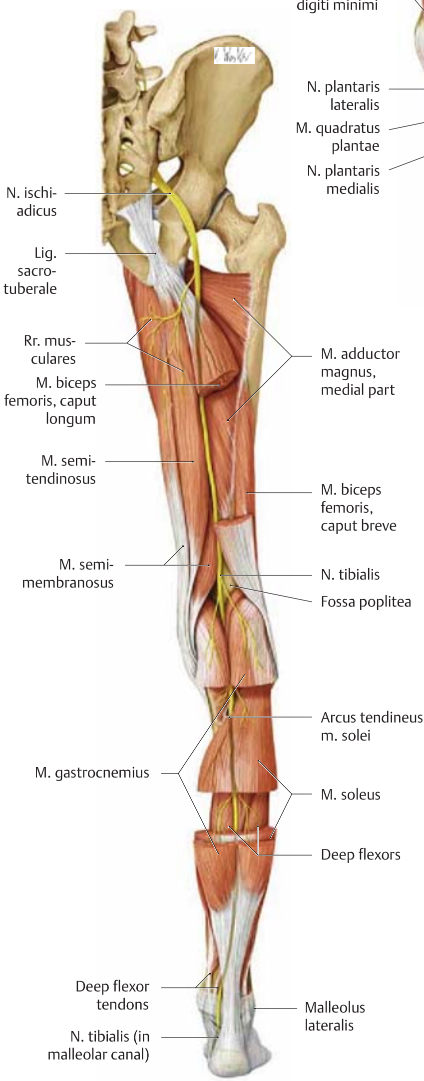


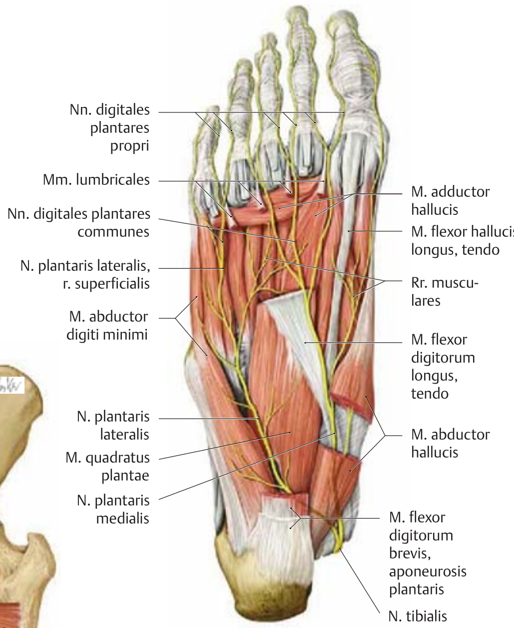
Table 27.6 N. fibularis communis (L4–S2)

Nerve	Innervated muscles	Sensory branches
Direct branches from n. ischiadicus	M. biceps femoris (caput breve)	–
N. fibularis superficialis	M. fibularis brevis and longus	N. cutaneus dorsalis medialis N. cutaneus dorsalis intermedius
N. fibularis profundus	M. tibialis anterior Mm. extensor digitorum brevis and longus Mm. extensor hallucis brevis and longus M. fibularis tertius	N. cutaneus hallucis lateralis N. cutaneus digiti secundi medialis

Fig. 27.24 **N. tibialis**
Right limb.



A Posterior view.



B Right foot, plantar view.

Fig. 27.25 **N. tibialis: Sensory distribution**
Right lower limb, posterior view.

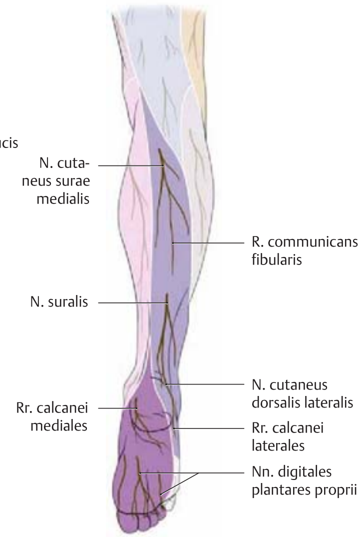
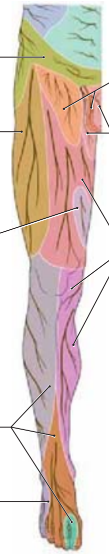


Table 27.7	**Tibial nerve (L4–S3)**	
Nerve	**Innervated muscles**	**Sensory branches**
Direct branches from n. ischiadicus	M. semitendinosus M. semimembranosus M. biceps femoris (caput longum) M. adductor magnus (medial part)	–
N. tibialis	M. triceps surae M. plantaris M. popliteus M. tibialis posterior M. flexor digitorum longus M. flexor hallucis longus	N. cutaneus surae mediales Rr. calcanei mediales and laterales N. cutaneus dorsalis lateralis
N. plantaris medialis	M. adductor hallucis M. flexor digitorum brevis M. flexor hallucis brevis (caput mediale) Mm. lumbricales pedis I	Nn. digitales plantares proprii
N. plantaris lateralis	M. flexor hallucis brevis (caput laterale) M quadratus plantae M. abductor digiti minimi M. flexor digiti minimi brevis M. opponens digiti minimi Mm. lumbricales pedis II–IV Mm. interossei plantares I–III Mm. interossei dorsales I–IV M. adductor hallucis	Nn. digitales plantares proprii

Superficial Nerves & Vessels of the Lower Limb

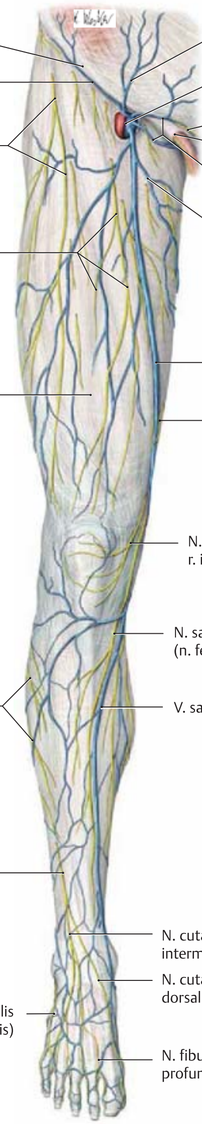
Fig. 27.26 **Cutaneous innervation: Anterior view**
Right limb.



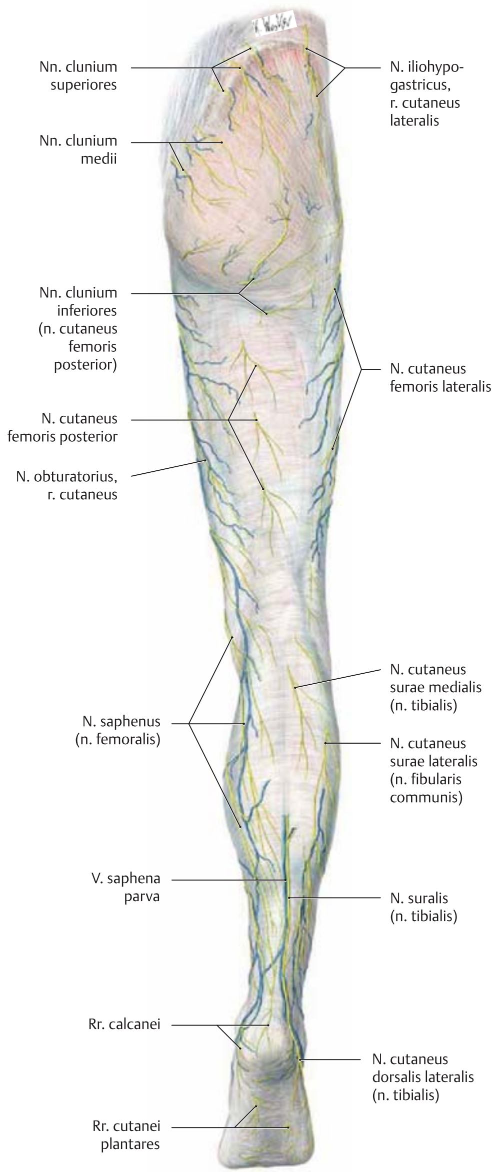
A Peripheral sensory cutaneous innervation.

B Segmental, radicular cutaneous innervation (dermatomes).

Fig. 27.27 **Superficial cutaneous veins and nerves**
Right limb.

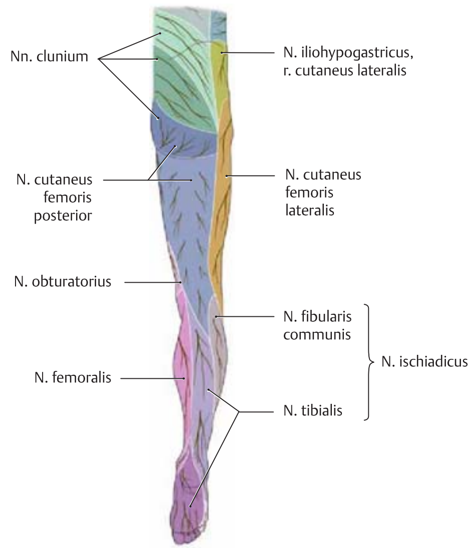


A Anterior view.

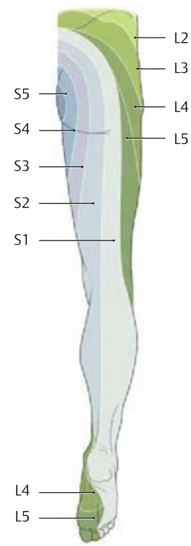


B Posterior view.

Fig. 27.28 **Cutaneous innervation: Posterior view**
Right limb.



A Peripheral sensory cutaneous innervation.



B Segmental, radicular cutaneous innervation (dermatomes).

Topography of Regio Inguinalis

Fig. 27.29 **Superficial veins and lymph nodes**
Right male regio inguinales, anterior view. *Removed:* Fascia cribrosa about hiatus saphenus.

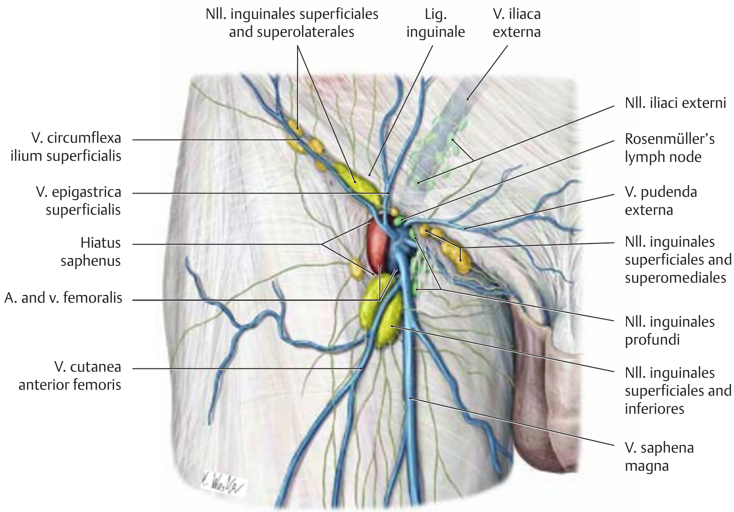
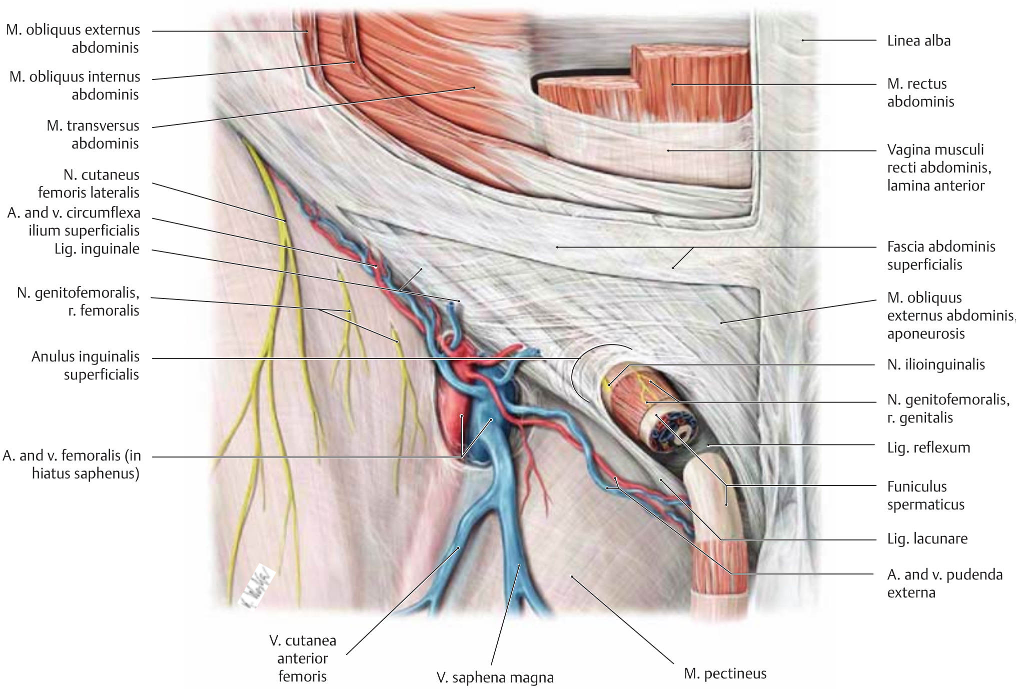


Fig. 27.30 **Regio inguinales**
Right male regio inguinales, anterior view.



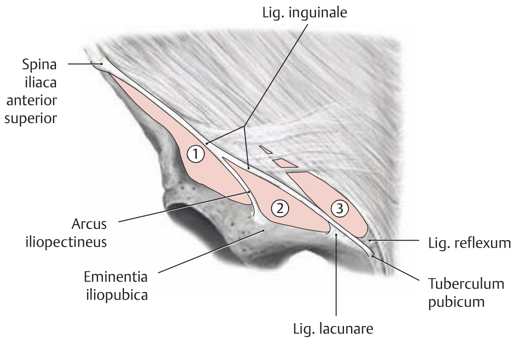
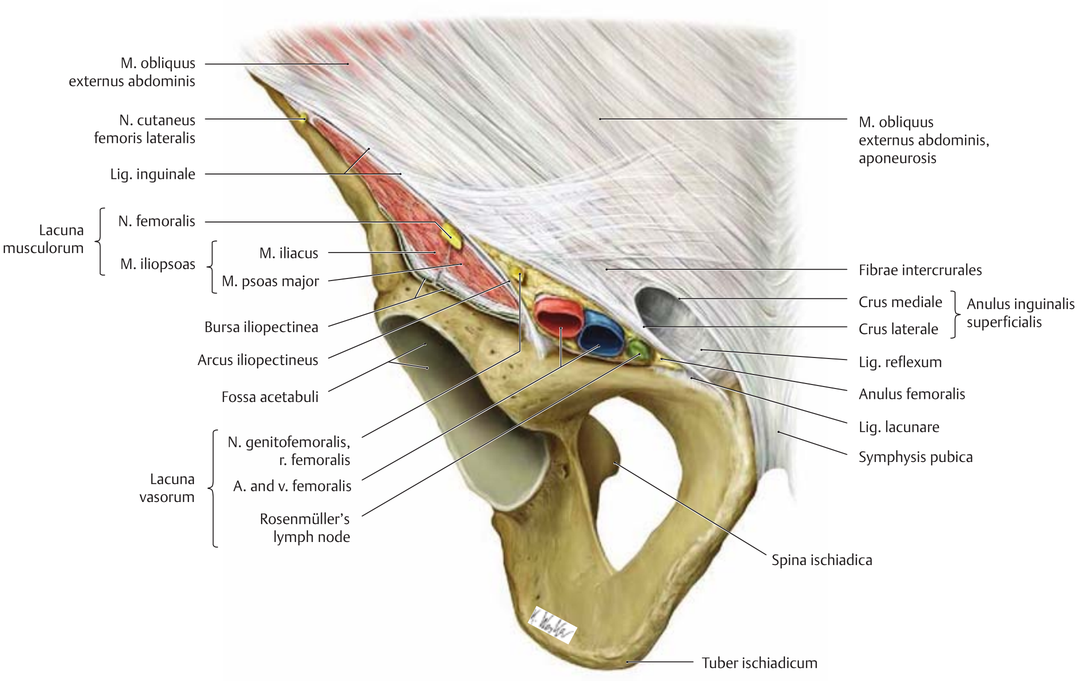


Table 27.8	Structures in the inguinal region	
Region	**Boundaries**	**Contents**
① Lacuna musculorum	Spina iliaca anterior superior Lig. inguinale Arcus iliopectineus	N. femoralis N. cutaneus femoris lateralis M. iliacus M. psoas major
② Lacuna vasorum	Lig. inguinale Arcus iliopectineus Lig. lacunare	A. and v. femoralis N. genitofemoralis (r. femoralis) Rosenmüller's lymph node
③ Anulus inguinalis superficialis	Crus mediale Crus laterale Lig. reflexum	N. ilioinguinalis N. genitofemoralis (r. genitalis) Funiculus spermaticus

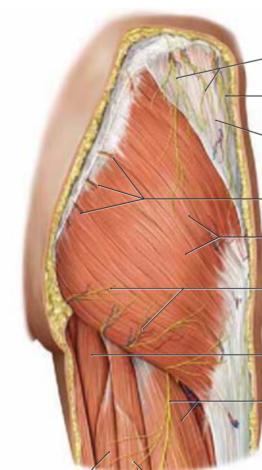
Fig. 27.31 **Lacunae musculorum and vasorum**
Right inguinal region, anterior view.



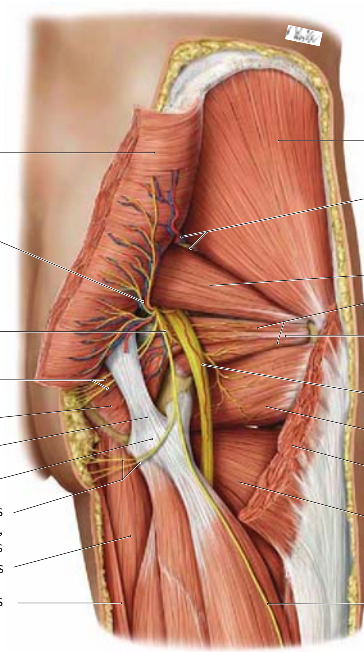
Topography of Regio Glutealis

Fig. 27.32 **Regio glutealis**
Right regio glutealis, posterior view.

A Fasciae and cutaneous neurovasculature.



B Regio glutealis. *Removed:* Fascia lata.



C Deep regio glutealis. *Partially removed:* M. gluteus maximus.

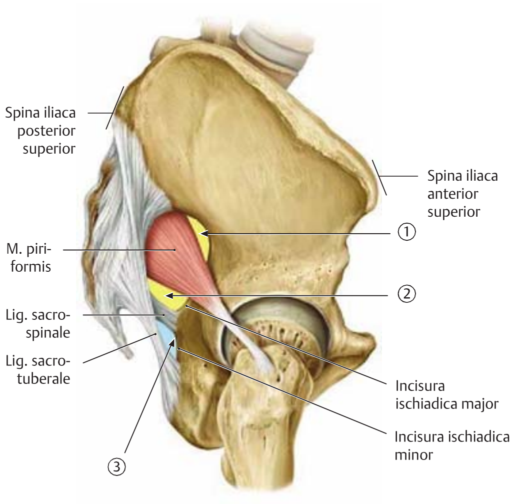
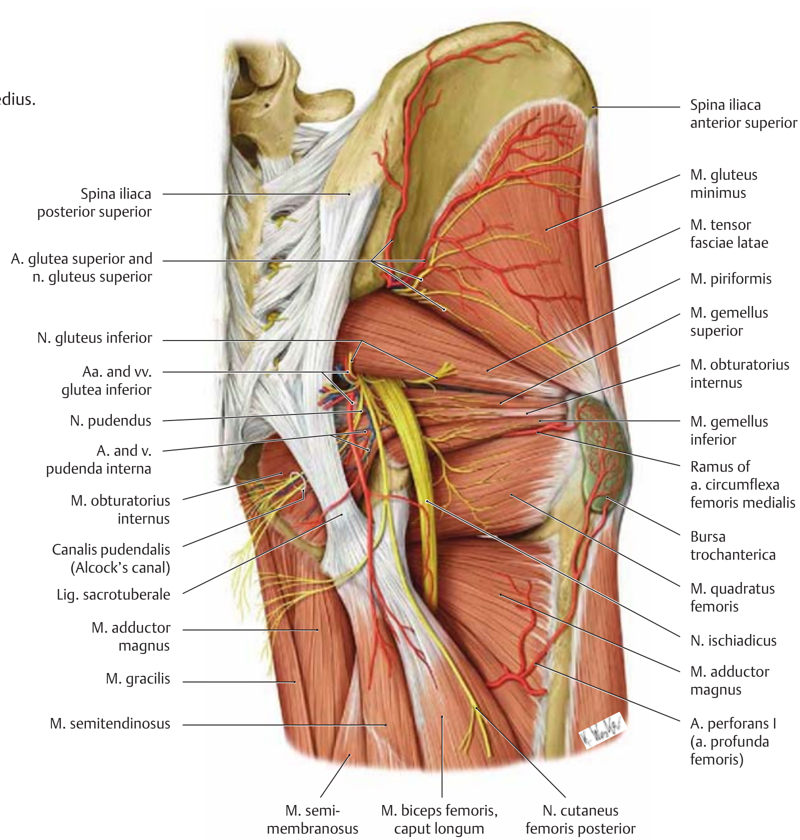


Table 27.9 Sciatic foramina

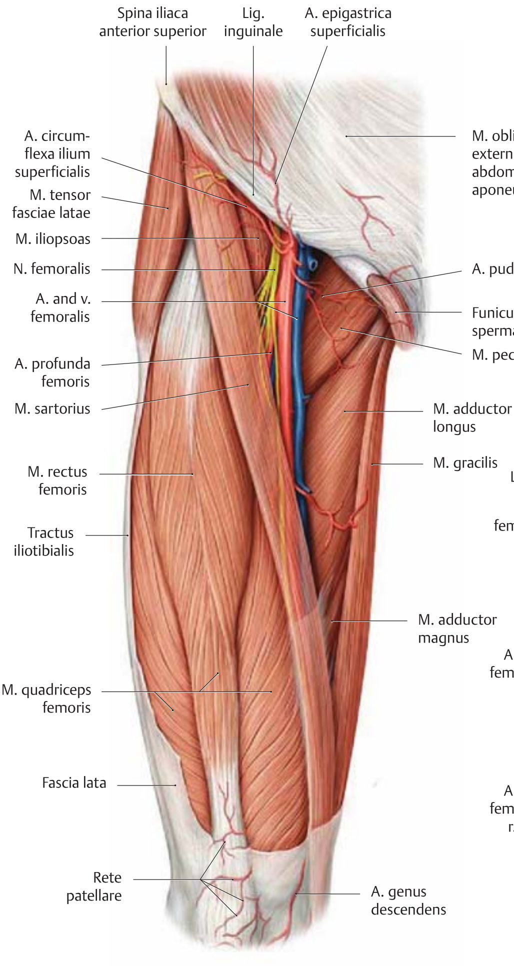
Foramen		Transmitted structures	Boundaries
Foramen ischiadicum majus	① Foramen suprapiriforme	A. and v. glutea superior N. gluteus superior	Incisura ischiadica major Lig. sacrospinale Os sacrum
	② Foramen infrapiriforme	A. and v. glutea inferior N. gluteus inferior A. and v. pudenda interna N. pudendus N. ischiadicus N. cutaneus femoris posterior	
③ Foramen ischiadicum minus		A. and v. pudenda interna N. pudendus M. obturatorius internus	Incisura ischiadica minor Lig. sacrospinale Lig. sacrotuberale

***Fig. 27.33* Regio glutealis and fossa ischioanalis**
Right regio glutealis, posterior view.
Removed: Mm. gluteus maximus and medius.

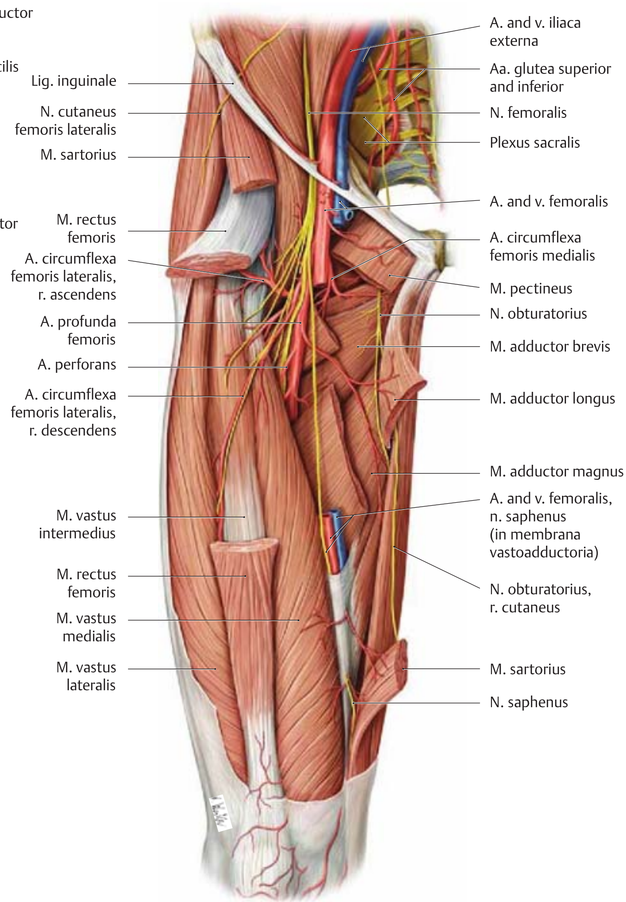


Topography of the Anterior & Posterior Thigh

Fig. 27.34 **Anterior thigh**
Right thigh, anterior view.



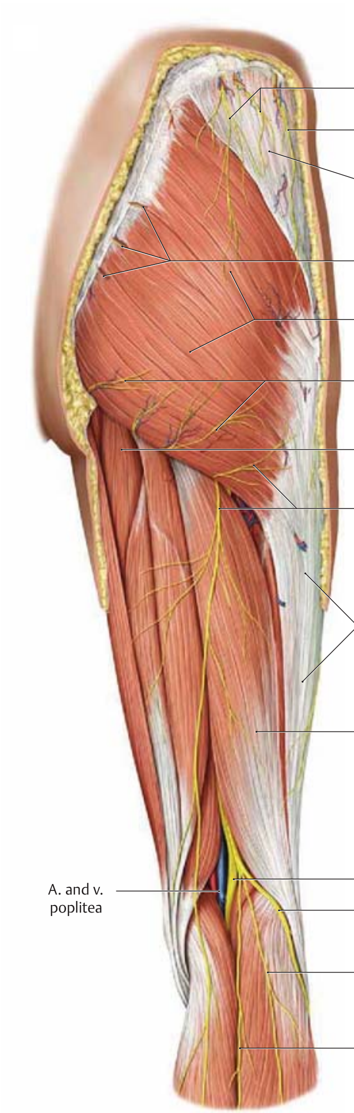
A Trigonum femoris. *Removed:* Skin, subcutaneous tissue, and fascia lata. *Windowed:* M. sartorius.



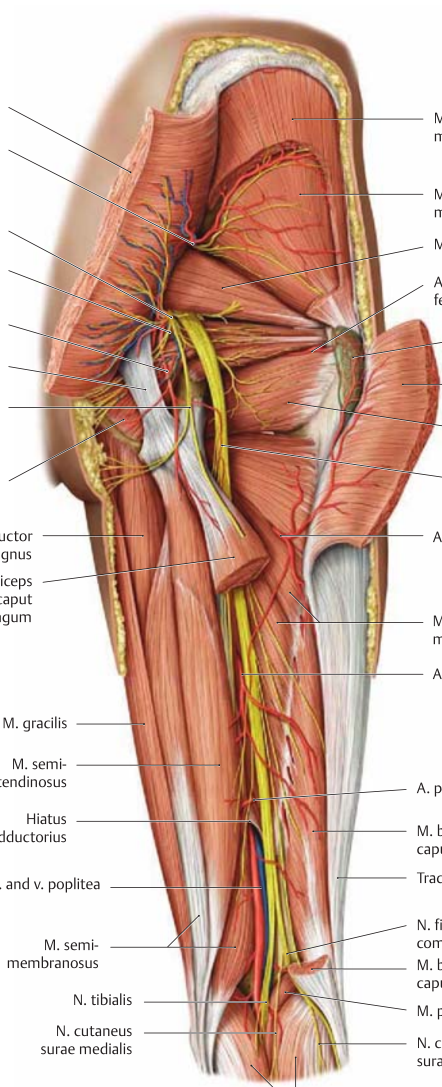
B Neurovasculature of the anterior thigh. *Removed:* Anterior abdominal wall. *Partially removed:* M. sartorius, m. rectus femoris, m. adductor longus, and m. pectineus.

Fig. 27.35 Posterior thigh

Right thigh, posterior view.



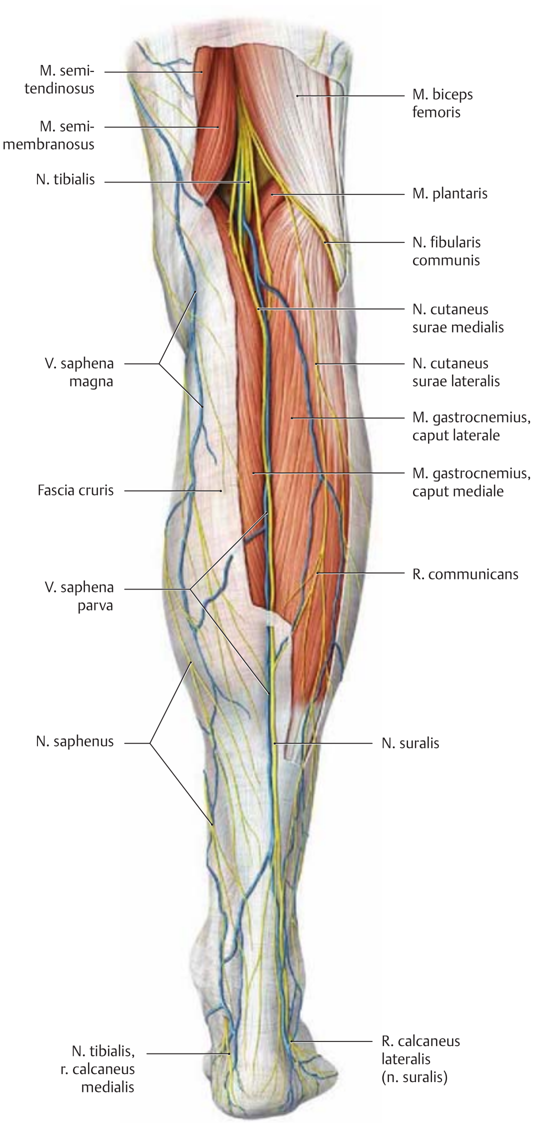
A Regio glutealis and thigh. *Removed:* Fascia lata.



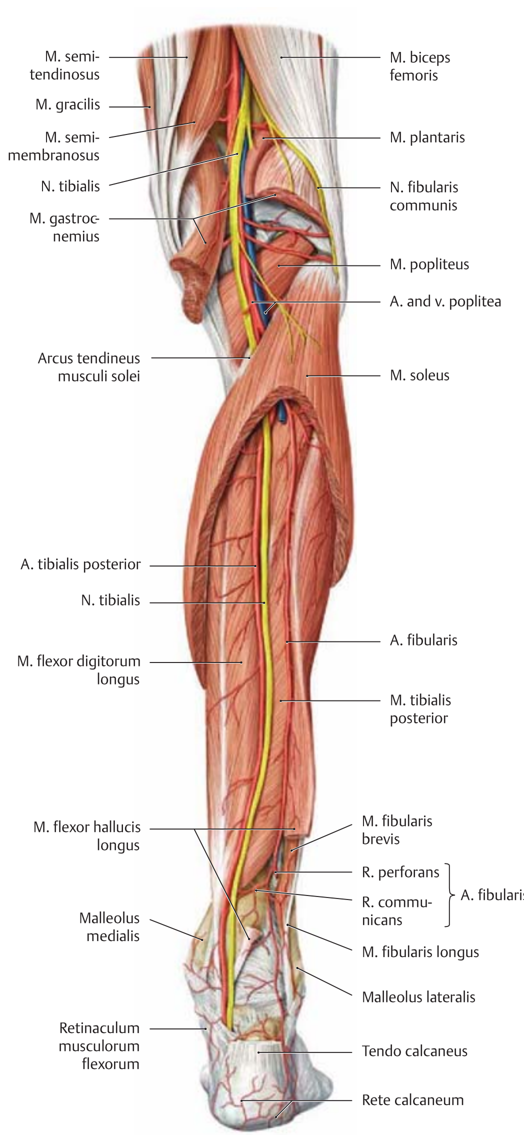
B Neurovasculature of the posterior thigh. *Partially removed:* M. gluteus maximus, m. gluteus medius, and m. biceps femoris. *Retracted:* M. semimembranosus.

Topography of the Posterior & Medial Leg

Fig. 27.36 **Posterior compartment**
Right leg, posterior view.

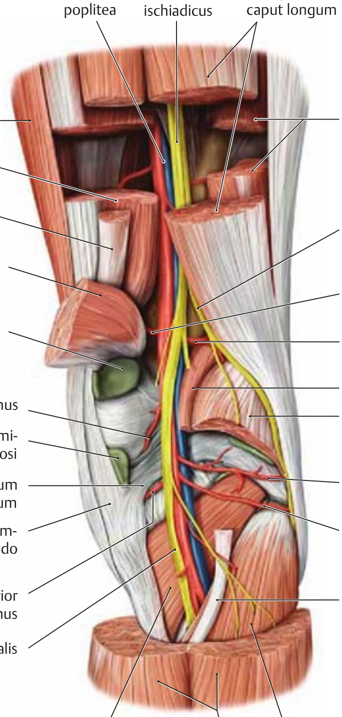


A Superficial neurovascular structures.

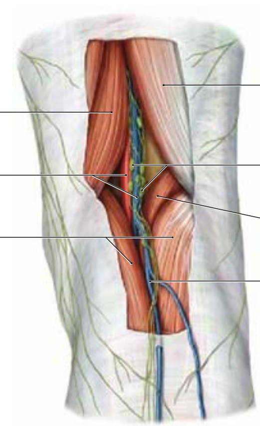


B Deep neurovascular structures.

Fig. 27.37 **Fossa poplitea**
Right leg, posterior view.

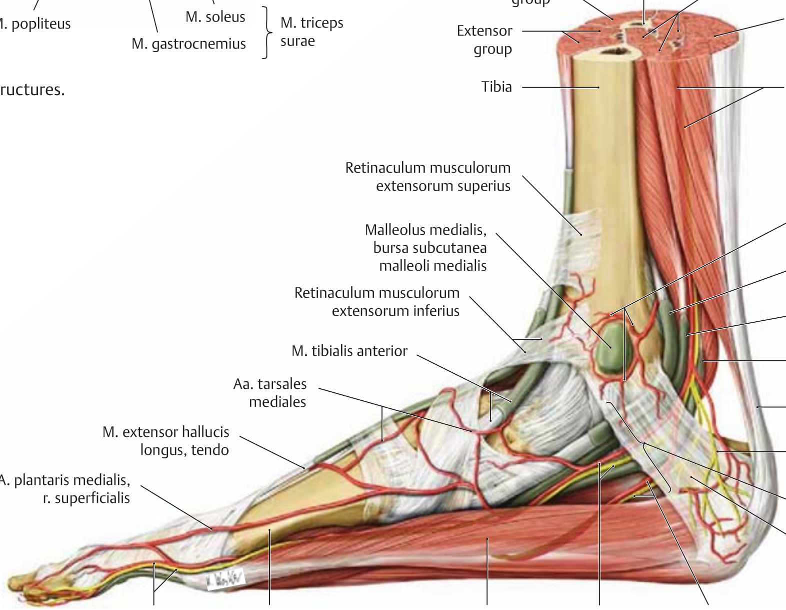


A Deep neurovascular structures.



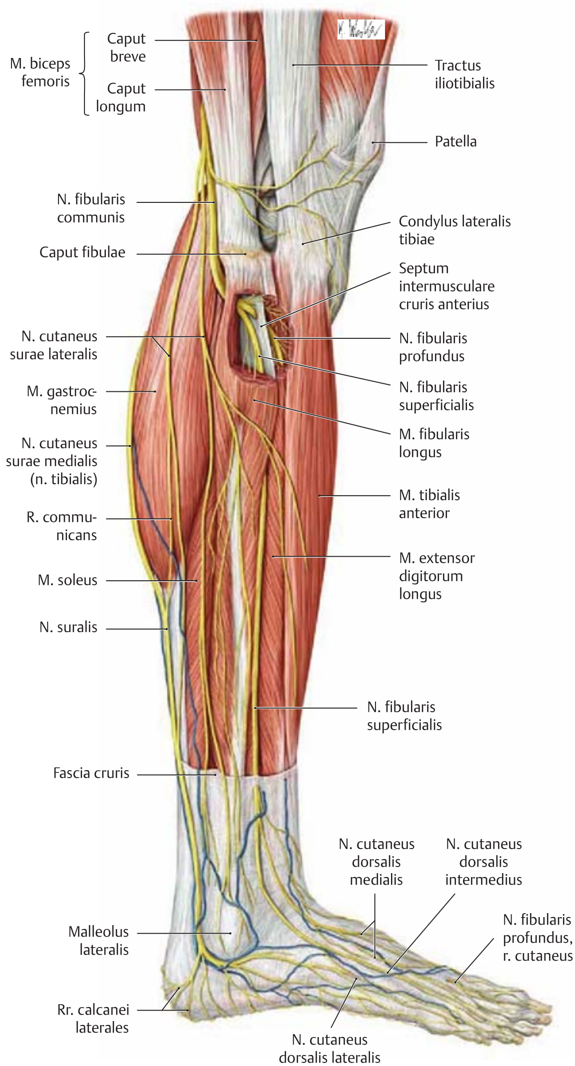
B Deep lymph nodes of fossa poplitea.

Fig. 27.38 **Posterior compartment: Medial view**
Right foot.



Topography of the Lateral & Anterior Leg

Fig. 27.39 Neurovasculature of the leg: Lateral view
Right limb. *Removed:* Origins of the m. fibularis longus and m. extensor digitorum longus.



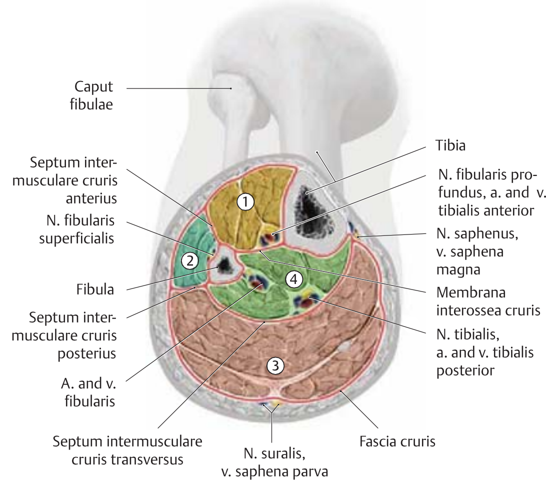


Table 27.10 Compartments of the leg

Compartment		Muscular contents	Neurovascular contents
① Compartimentum cruris anterius		M. tibialis anterior	N. fibularis profundus A. and v. tibialis anterior.
		M. extensor digitorum longus	
		M. extensor hallucis longus	
		M. fibularis tertius	
② Compartimentum cruris laterale		M. fibularis longus	N. fibularis superficialis
		M. fibularis brevis	
Compartimentum crusis posterius	③ Pars superficialis	M. triceps surae (m. gastrocnemius and m. soleus)	—
		M. plantaris	
	④ Pars profunda	M. tibialis posterior	N. tibialis A. and v. tibialis posterior A. and v. fibularis
		M. flexor digitorum longus	
		M. flexor hallucis longus	

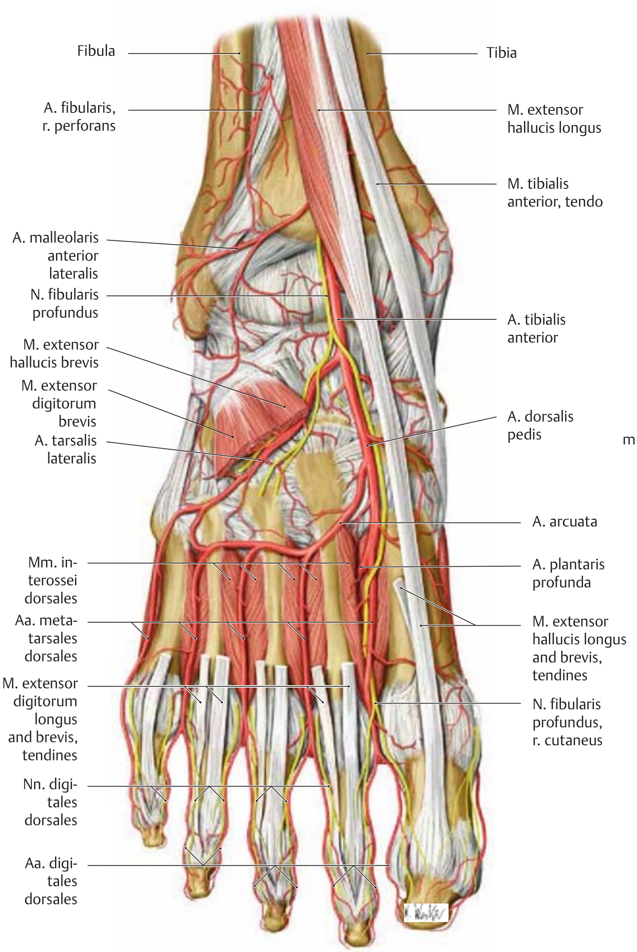
Clinical

Compartment syndrome

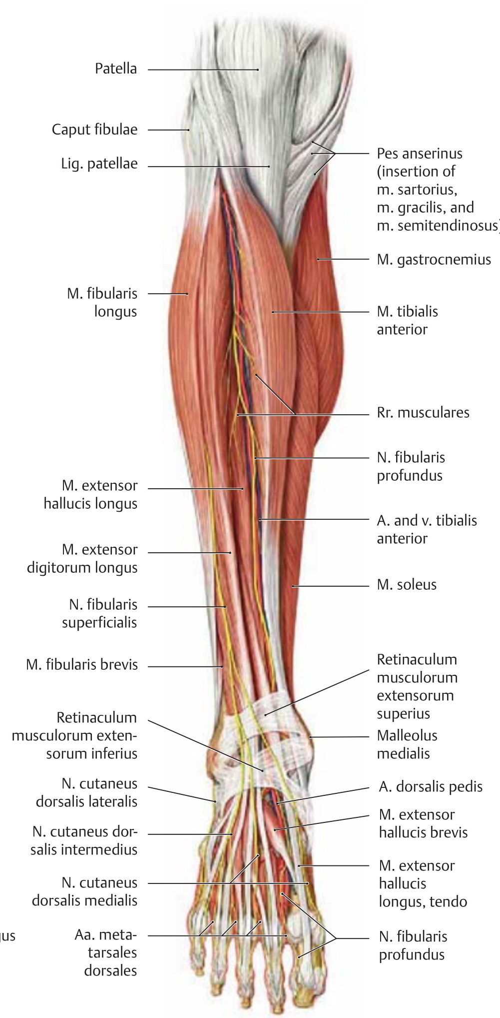
Muscle edema or hematoma can lead to a rise in tissue pressure in the compartments of the leg. Subsequent compression of neurovascular structures may cause ischemia and irreversible muscle and nerve damage. Patients with *anterior* compartment syndrome, the most common form, suffer excruciating pain and cannot dorsiflex the toes. Emergency incision of the fascia of the leg may be performed to relieve compression.

Fig. 27.40 Neurovasculature of the leg and foot: Anterior view

Right limb with foot in plantar flexion.



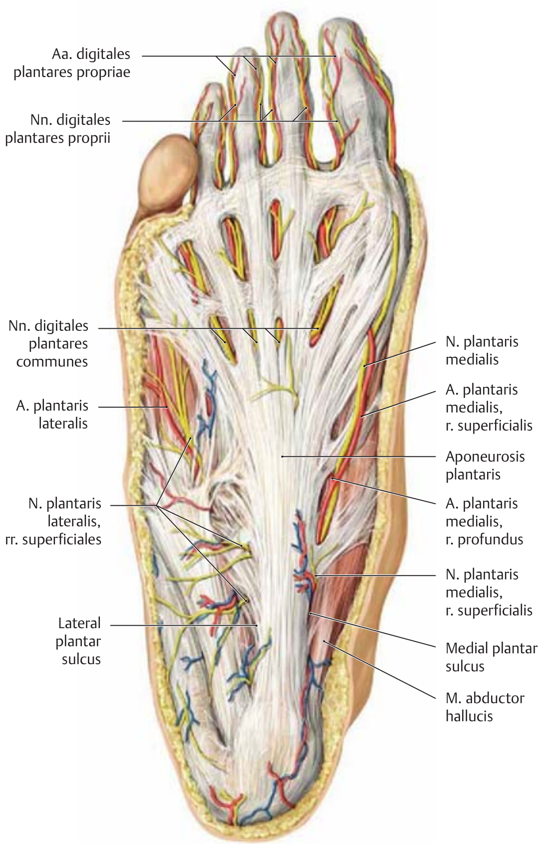
A Neurovasculature of the dorsum.



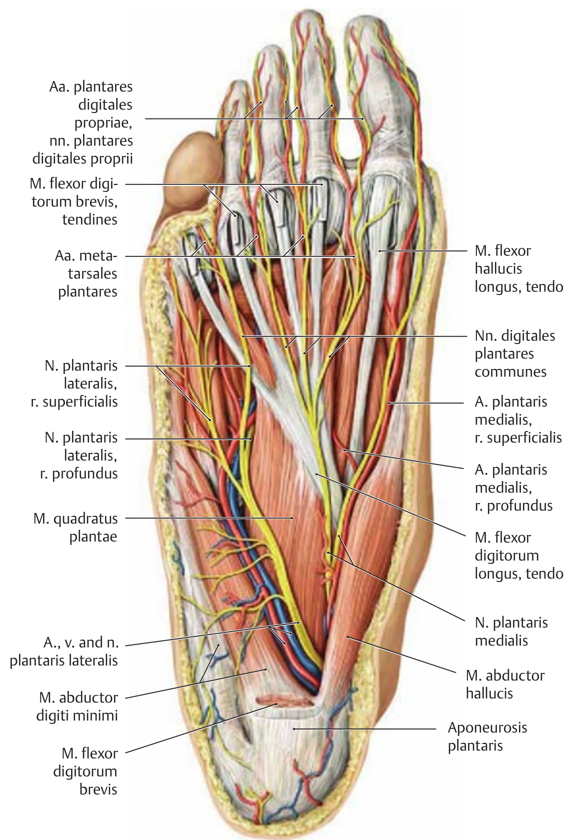
B Neurovasculature of the leg. *Removed:* Skin, subcutaneous tissue, and fasciae. *Retracted:* M. tibialis anterior and m. extensor hallucis longus.

Topography of Planta Pedis

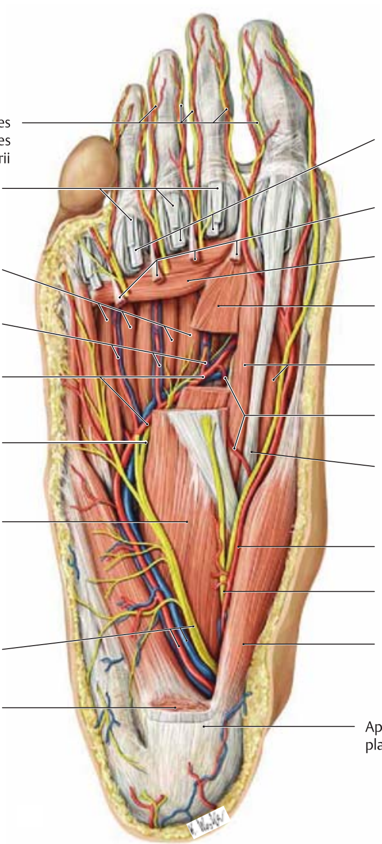
Fig. 27.41 **Neurovasculature of the foot: Sole**
Right foot, plantar view.



A Superficial layer. *Removed:* Skin, subcutaneous tissue, and fascia.

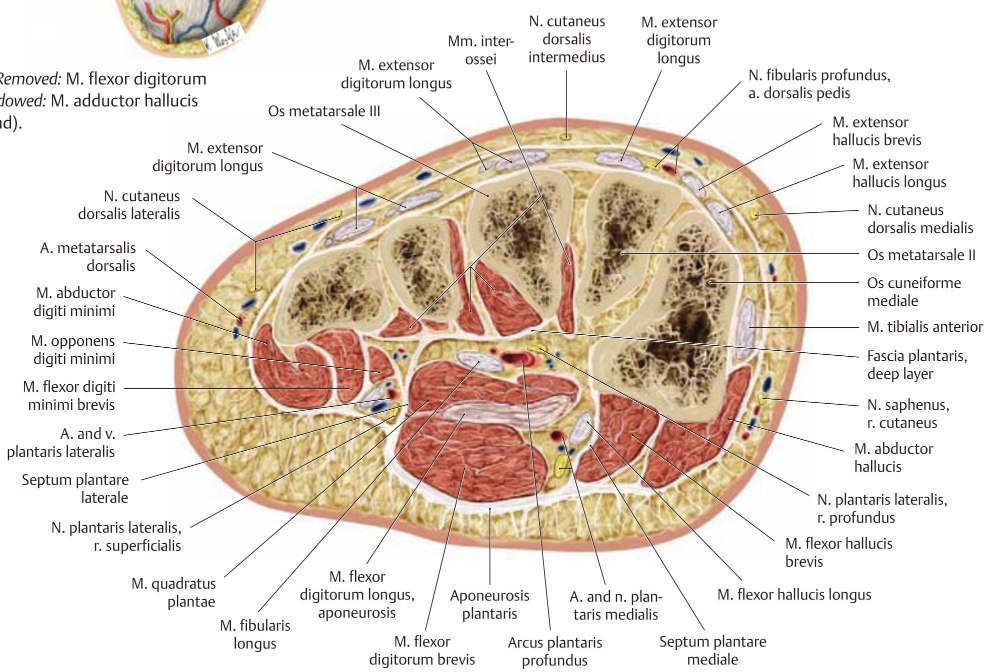


B Middle layer. *Removed:* Plantar aponeurosis and m. flexor digitorum brevis.



C Deep layer. *Removed:* M. flexor digitorum longus. *Windowed:* M. adductor hallucis (oblique head).

Fig. 27.42 **Neurovasculature of the foot: Cross section**
Coronal section, distal view.



Transverse Sections of the Thigh & Leg

Fig. 27.43 **Windowed dissection**
Right limb, posterior view.

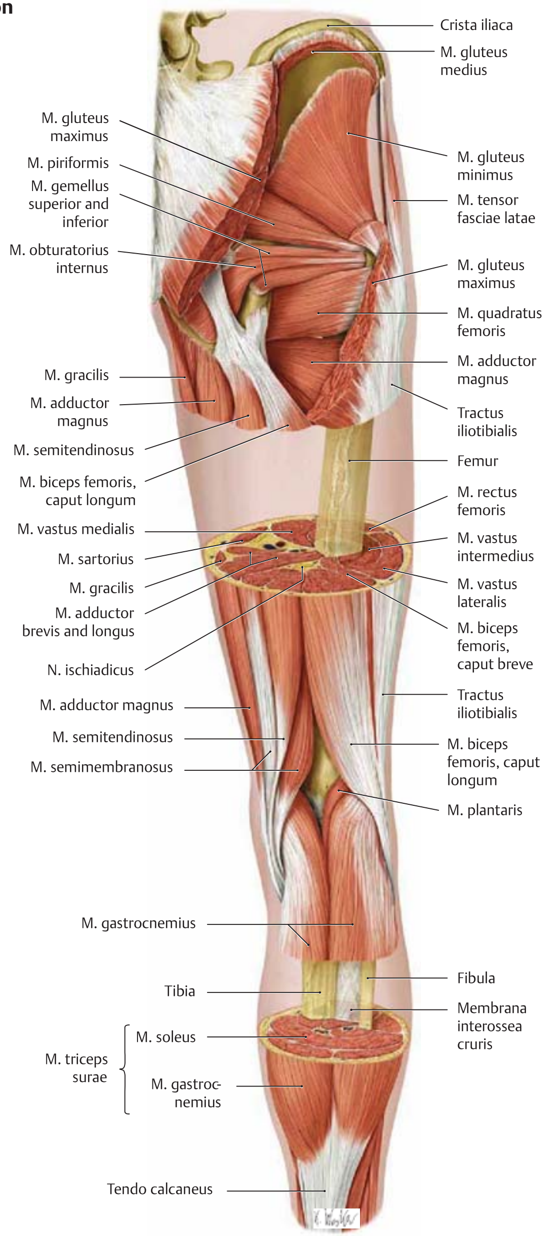
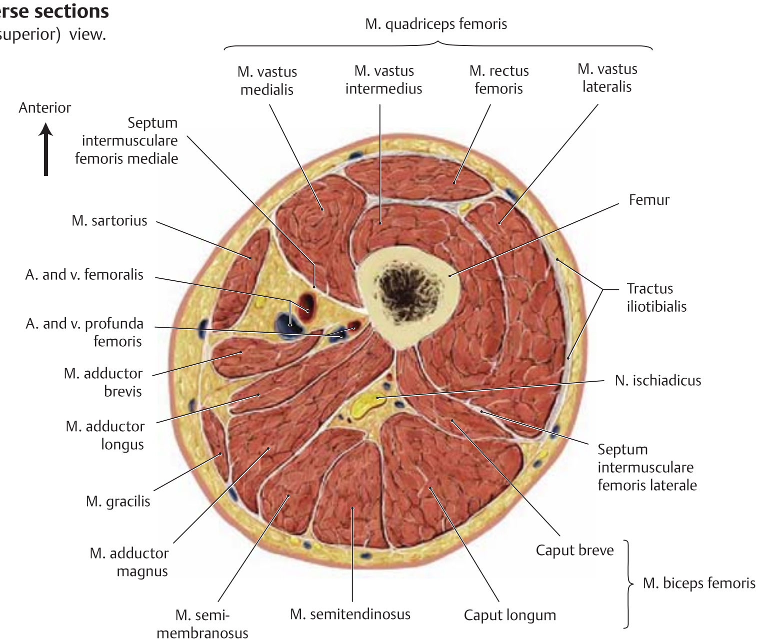
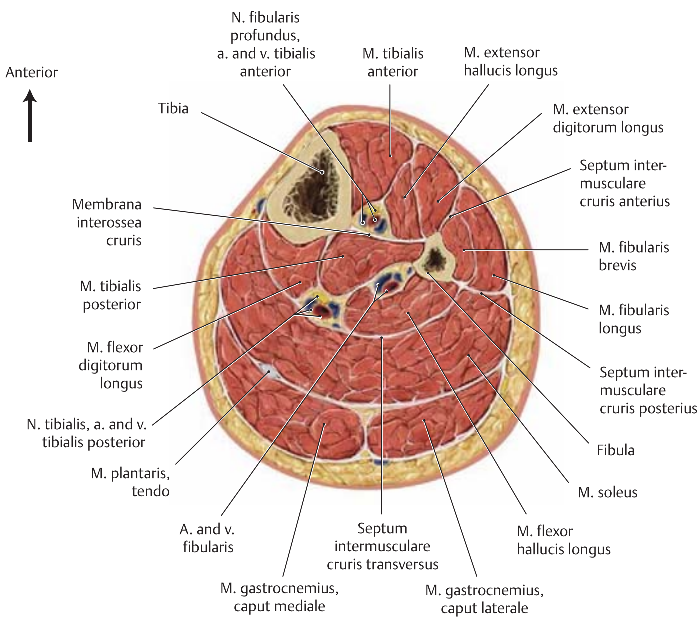


***Fig. 27.44* Transverse sections**
Right limb, proximal (superior) view.



A Thigh (plane of section in Fig. 27.43).

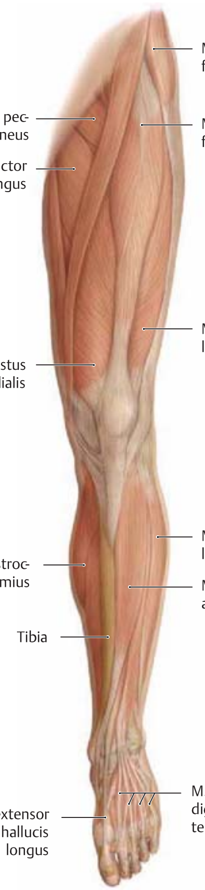


B Leg (plane of section in Fig. 27.43).

Surface Anatomy

Fig. 28.1 **Lower limb: Anterior view**

A Surface anatomy, right limb.



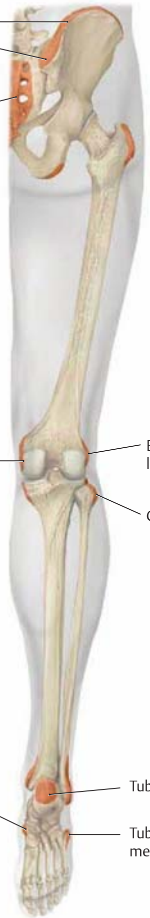
B Musculature, left limb.

Fig. 28.2 **Palpable bony prominences**
Right limb.

A Anterior view.

Q1: The articulatio coxae is not directly palpable. How would you correctly locate caput femoris based on surface anatomy?

Fig. 28.3 Lower limb: Posterior view



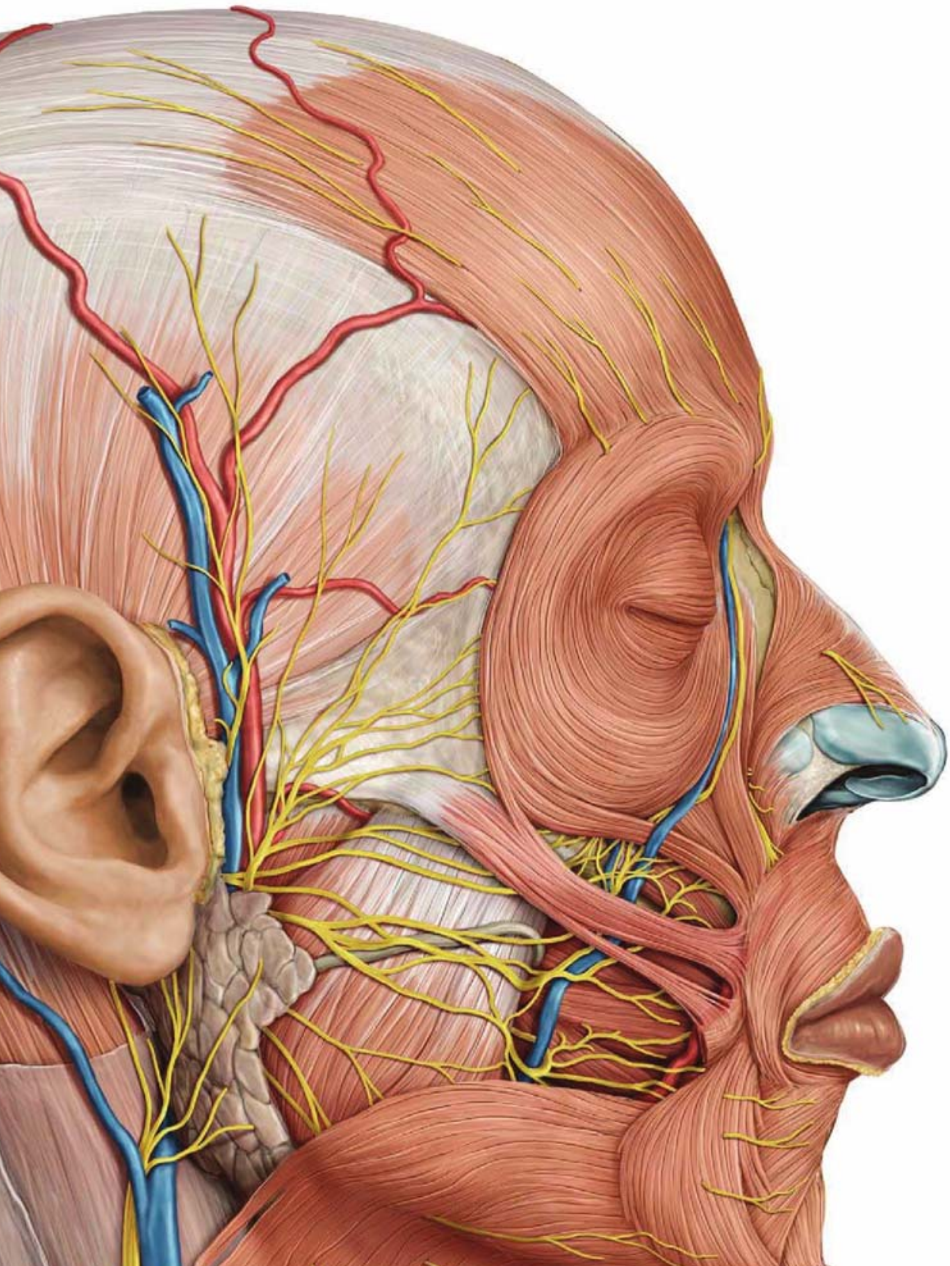
B Posterior view.

A Surface anatomy, left limb.

B Musculature, right limb.

Q2: Which palpable landmarks would you use to locate n. ischiadicus (in regio glutealis), n. fibularis communis (at the knee), and the n. tibialis (at the ankle)?

See answers beginning on p. 626.



Head & Neck

29 Bones of the Head

30 Muscles of the Skull & Face

31 Cranial Nerves

32 Neurovasculature of the Skull & Face

33 Orbit & Eye

34 Nasal Cavity & Nose

35 Temporal Bone & Ear

36 Oral Cavity & Pharynx

37 Neck

38 Surface Anatomy

Anterior & Lateral Skull

Fig. 29.1 Lateral skull
Left lateral view.

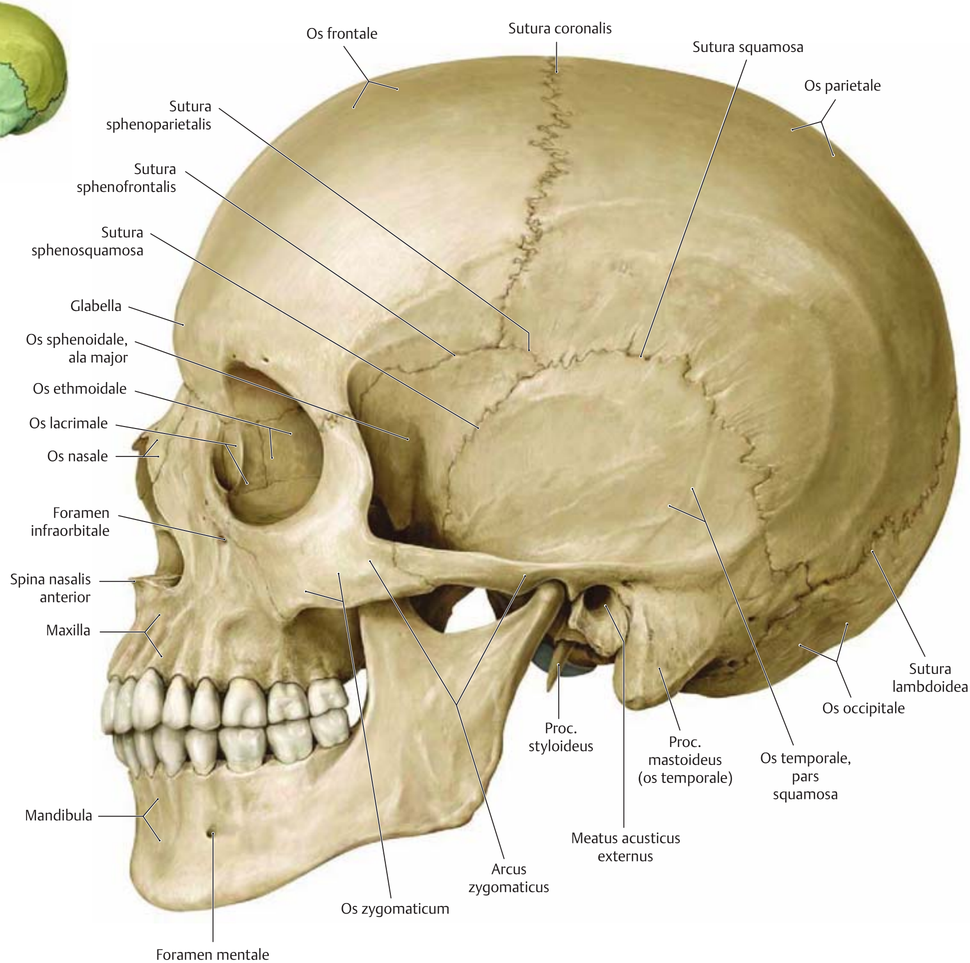


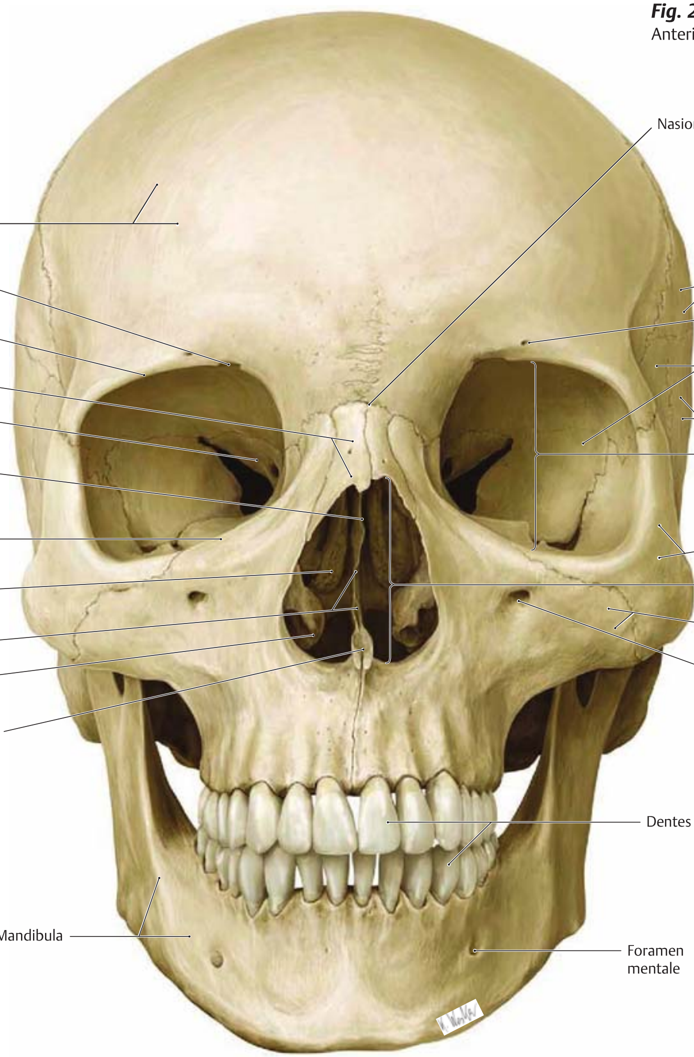
Table 29.1 Bones of the skull

The caput is subdivided into the neurocranium (gray) and viscerocranium (orange). The neurocranium protects the encephalon, while the viscerocranium houses and protects the facial regions.

Neurocranium	Viscerocranium	
• Os ethmoidale (lamina cribrosa)* • Os frontale • Os occipitale • Os parietale • Os sphenoidale • Os temporale (pars petrosa and pars squamosa)	• Os ethmoidale • Os hyoideum • Concha nasalis inferior • Os lacrimale • Os sphenoidale (proc. pterygoideus) • Os temporale • Vomer	• Mandibula • Maxilla • Os nasale • Os palatinum

*Most of the os ethmoidale is in the viscerocranium; most of the os sphenoidale is in the neurocranium. The os temporale is divided between the two.

Fig. 29.2 Anterior skull
Anterior view.



Clinical

Fractures of the face

The framelike construction of the facial skeleton leads to characteristic patterns for fracture lines (classified as Le Fort I, II, and III fractures).

A Le Fort I. **B** Le Fort II. **C** Le Fort III.

Posterior Skull & Calvaria

Fig. 29.3 **Posterior skull**
Posterior view.

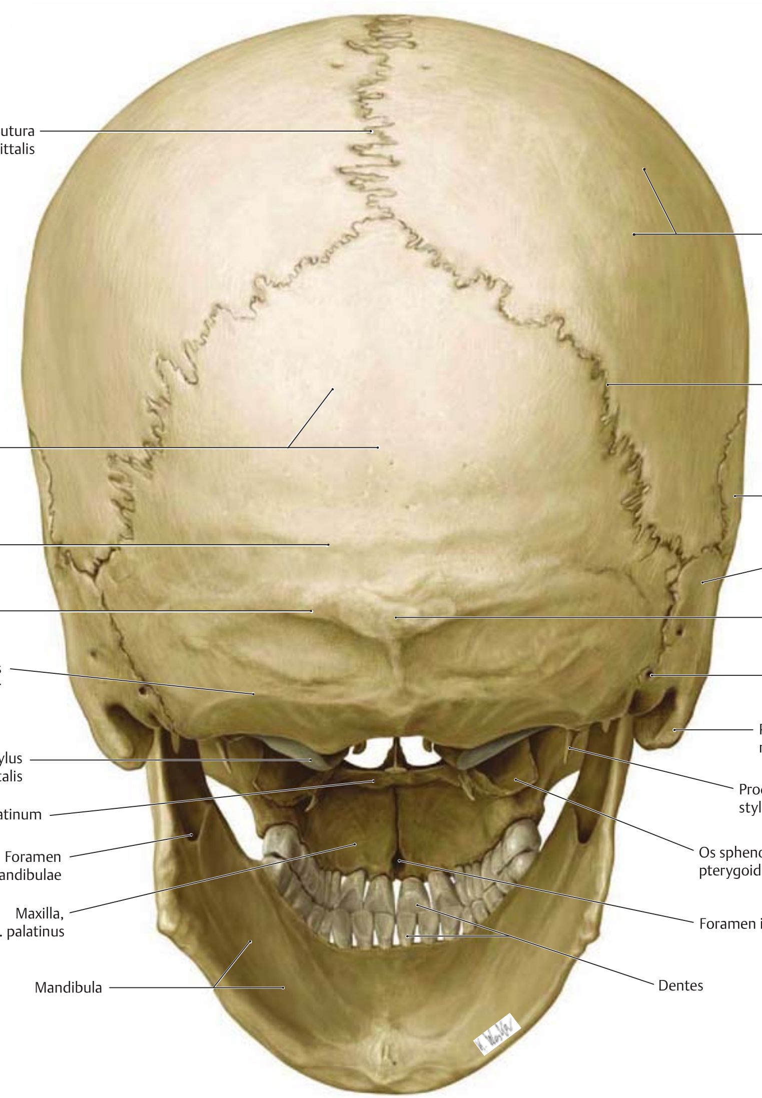
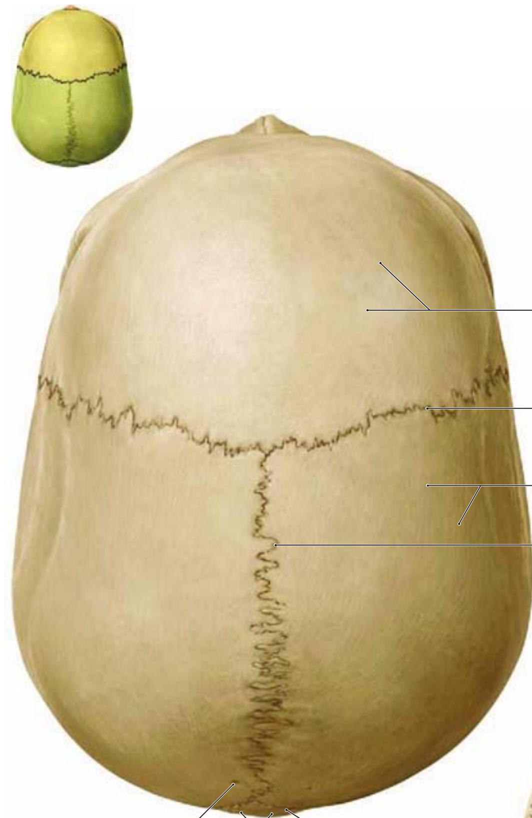
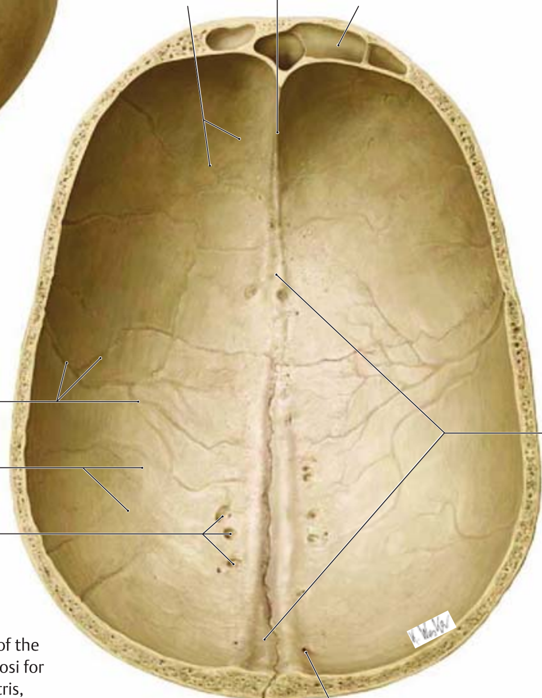


Fig. 29.4 **Calvaria**

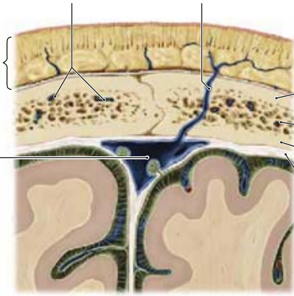


A External calvaria, superior view.



B Internal calvaria, inferior view. The interior of the calvaria is marked by sulci arteriosi and venosi for the meningeal arteries and sinus durae matris, respectively, and foveolae granulares for the granulationes arachnoideae (see pp. 606–610).

Fig. 29.5 **Structure of the calvaria**
Cross section.



Base of the Skull

Fig. 29.6 **Base of the skull: Exterior**
Inferior view. *Revealed:* Foramina and canals for blood vessels (see p. 490) and cranial nerves. *Note:* This view allows visual access into the posterior region of the nasal cavity.

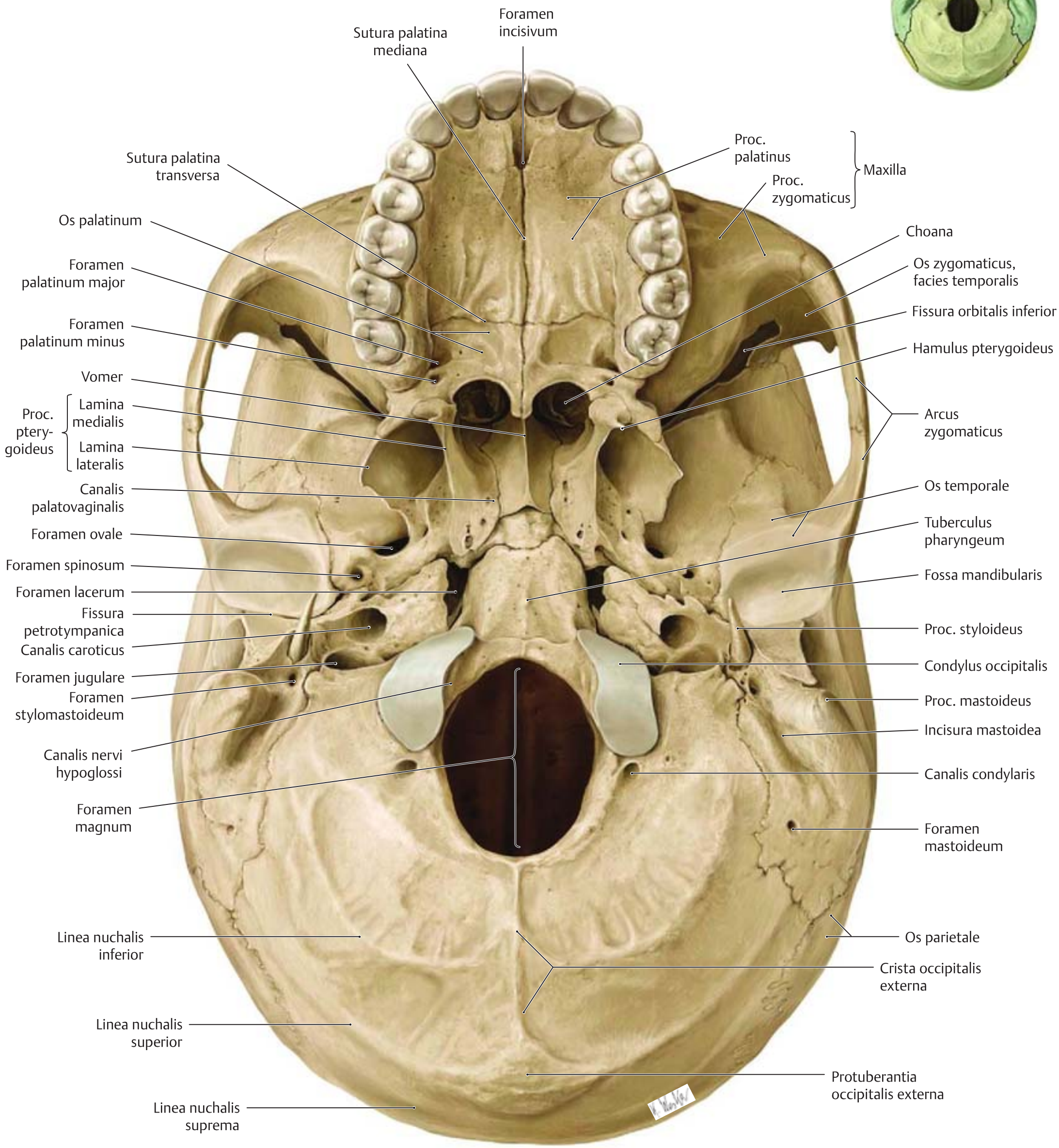
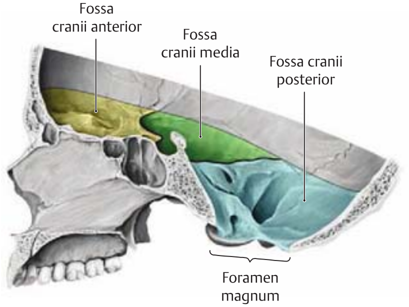
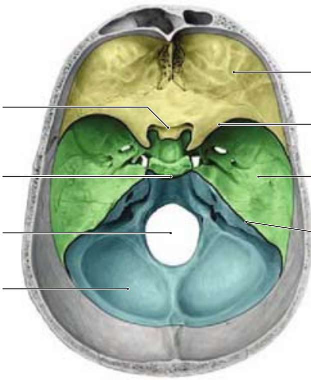


Fig. 29.7 **Cranial fossae**
The interior of the skull base consists of three successive fossae that become progressively deeper in the frontal-to-occipital direction.

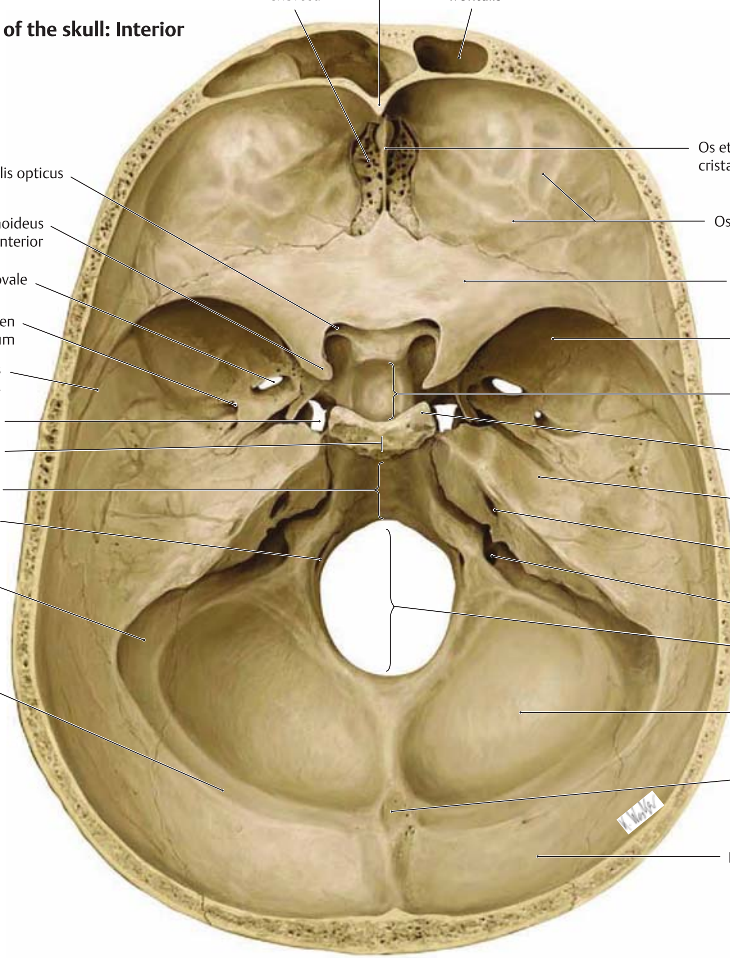


A Midsagittal section, left lateral view.



B Superior view of opened skull.

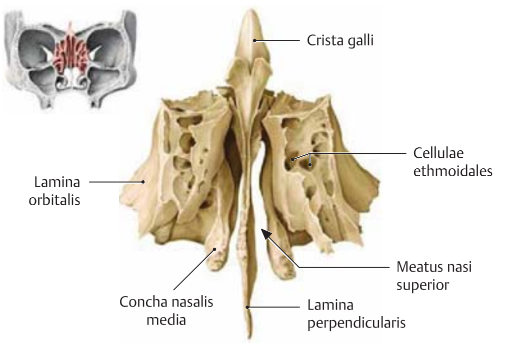
Fig. 29.8 **Base of the skull: Interior**
Superior view.



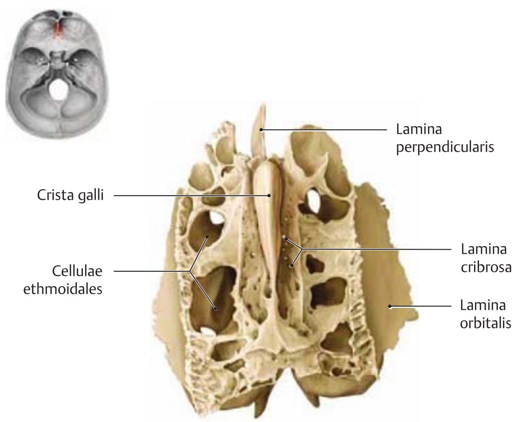
Os Ethmoidale & Os Sphenoidale

The structurally complex os ethmoidale and os sphenoidale are shown here in isolation. The other bones of the skull are shown in their respective regions: orbita (see pp. 506–507), nasal cavity (see pp. 520–521), oral cavity (see pp. 538–539), and ear (see pp. 526–527).

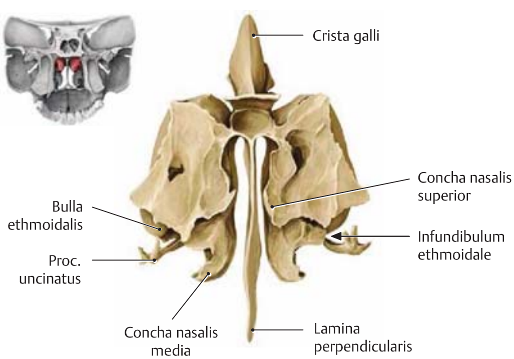
Fig. 29.9 Os ethmoidale
The os ethmoidale is the central bone of the nose and paranasal air sinuses (see pp. 520–523).



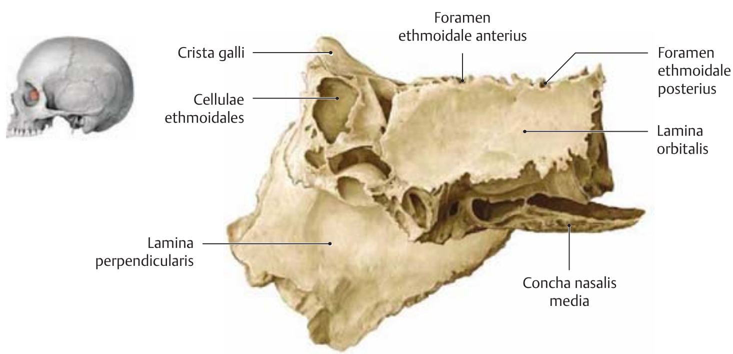
A Anterior view.



B Superior view.

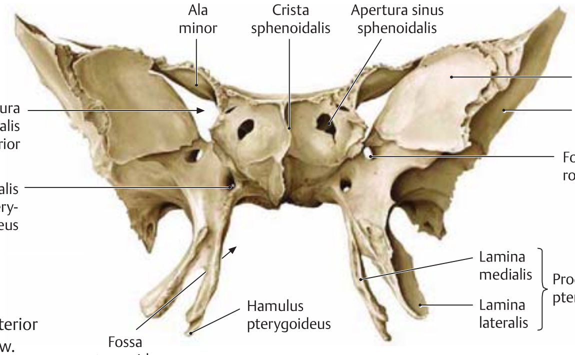


C Posterior view.

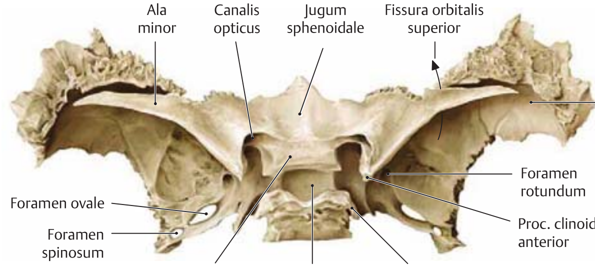


D Left lateral view.

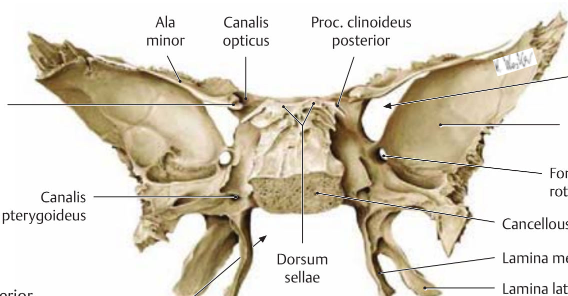
Fig. 29.10 Os sphenoidale
The os sphenoidale is the most structurally complex bone in the human body.



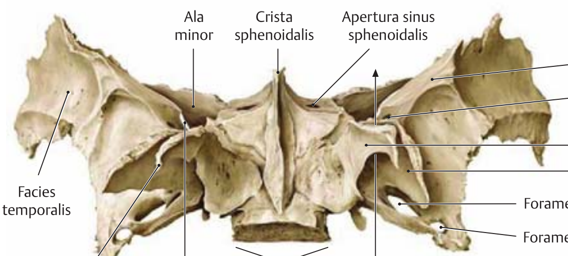
A Anterior view.



B Superior view.



C Posterior view.

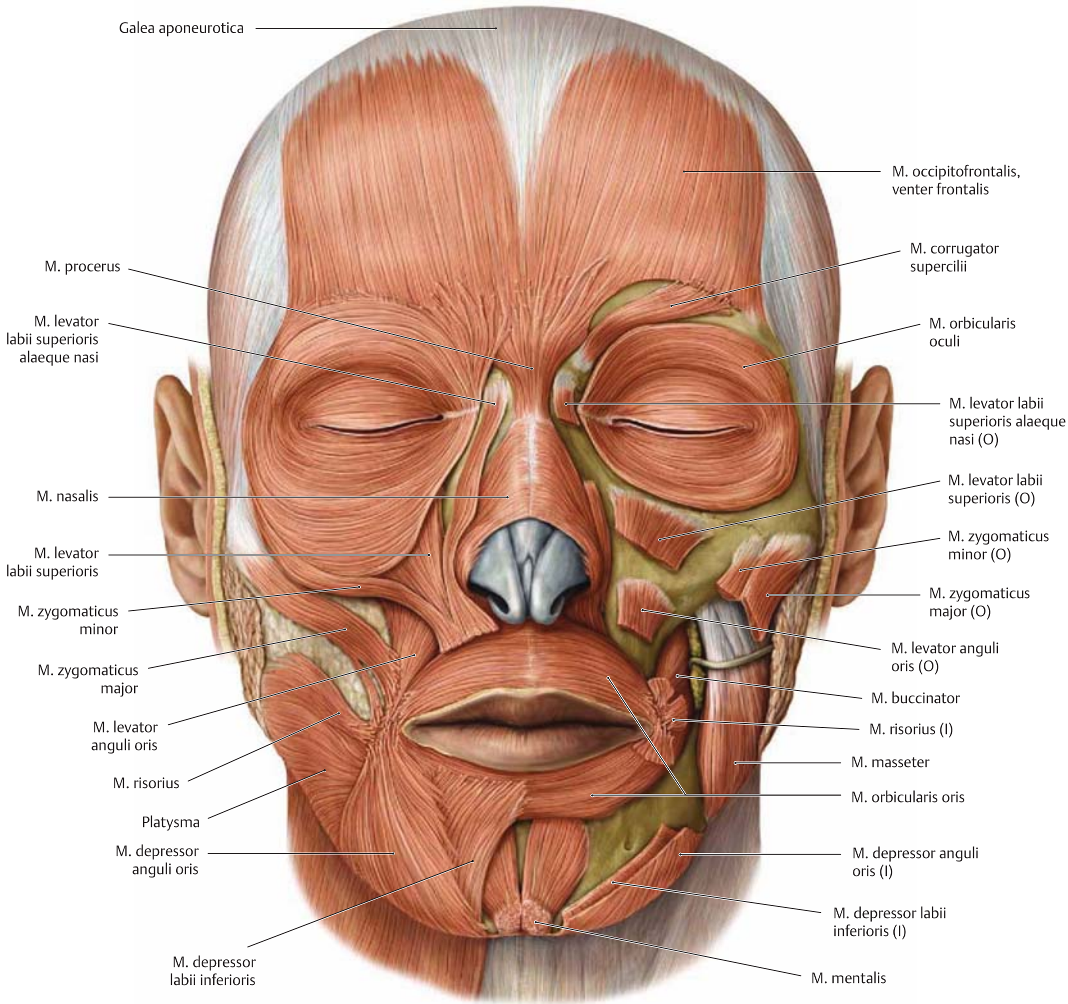


D Inferior view. *Note:* The vomer sits below the crista sphenoidalis (see p. 538).

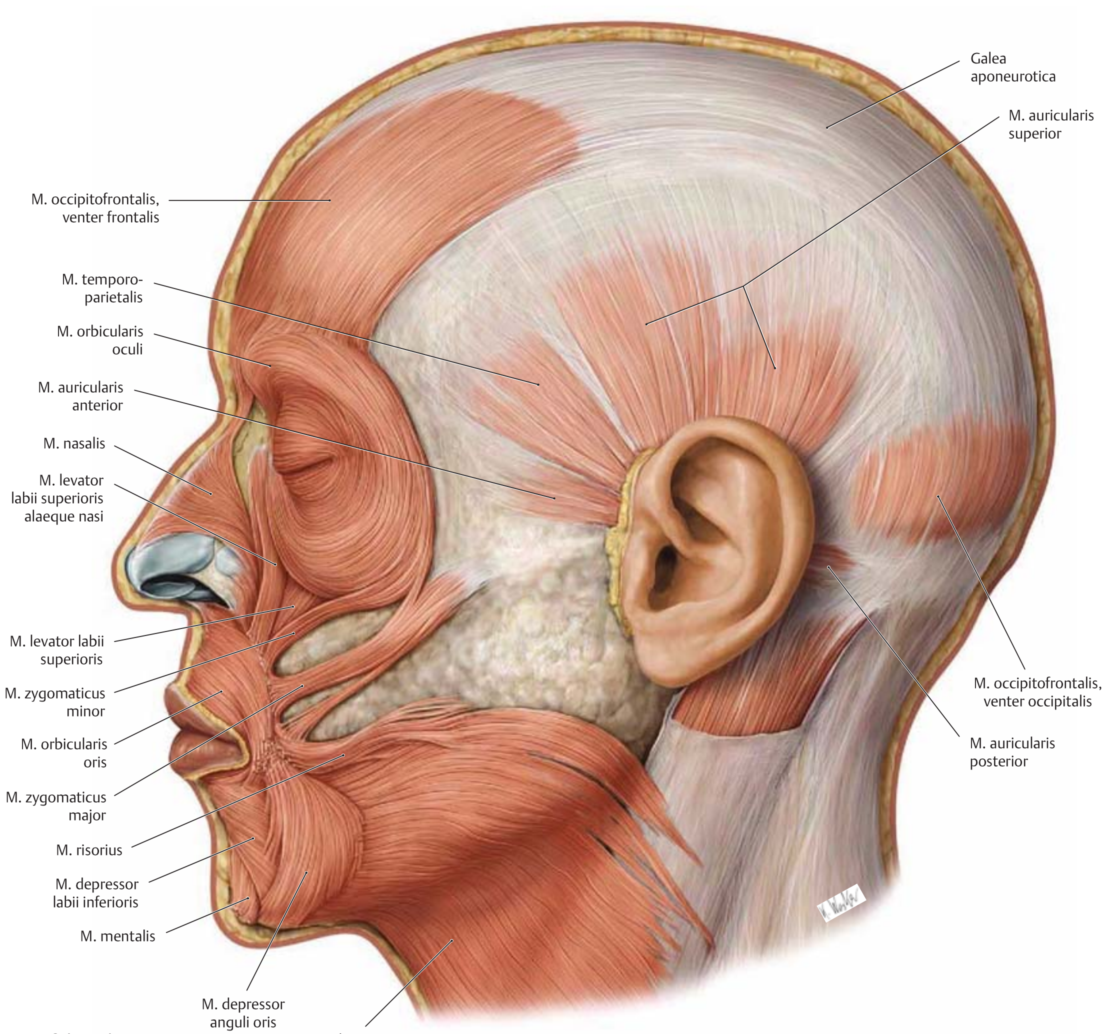
Muscles of Facial Expression & of Mastication

The muscles of the skull and face are divided into two groups. The muscles of facial expression make up the superficial muscle layer in the face. The muscles of mastication are responsible for the movement of the mandible during mastication (chewing).

Fig. 30.1 Muscles of facial expression (Musculi faciei)

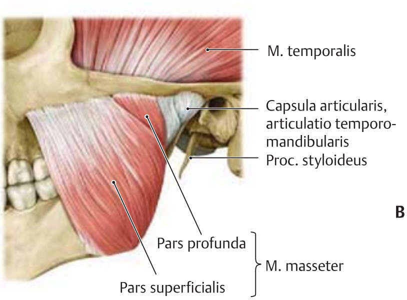


A Anterior view. Muscle origins (O) and insertions (I) indicated on left side of face.

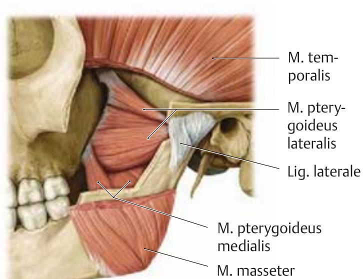


B Left lateral view.

Fig. 30.2 **Muscles of mastication (Musculi masticatorii)**
Left lateral view.



A Superficial layer.



B Deep layer. *Removed:* Mandibula (processus coronoideus) and lower m. temporalis.

Muscle Origins & Insertions on the Skull

Fig. 30.3 **Lateral skull: Origins and insertions**
Left lateral view. Muscle origins (red), insertions (blue).
Note: There are generally no bony insertions for the muscles of facial expression. These muscles insert into skin and other muscles of facial expression.

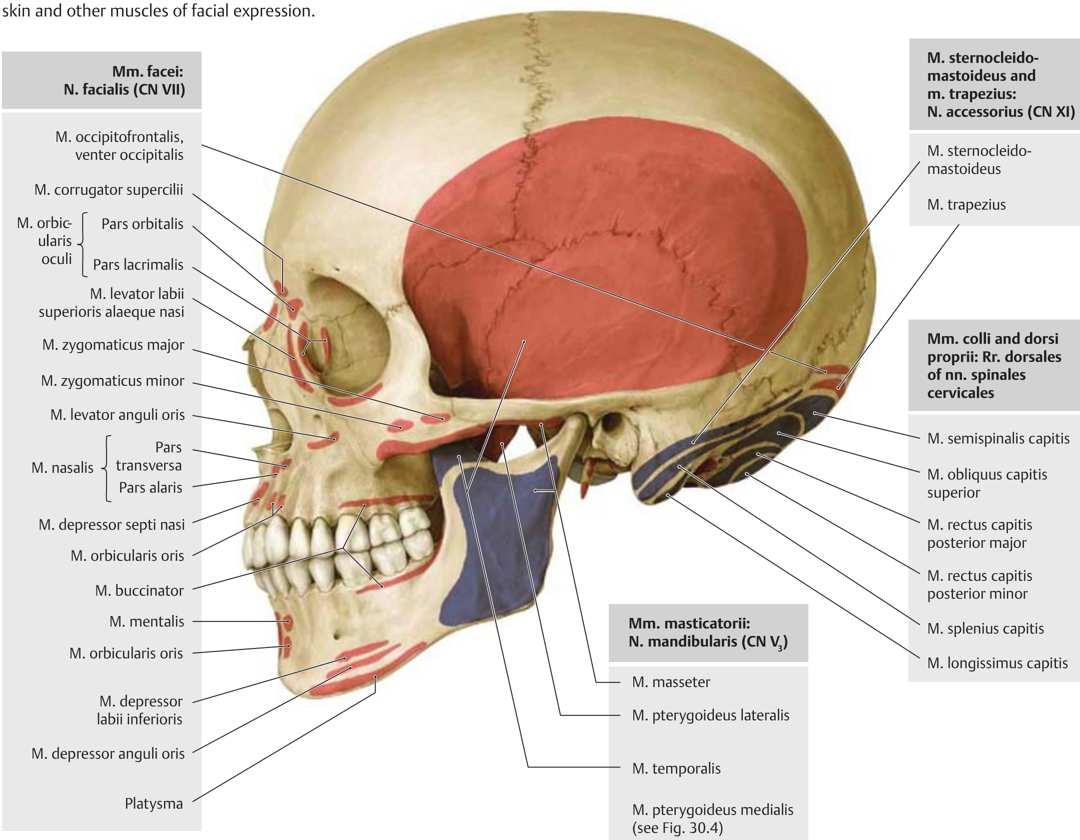


Fig. 30.4 **Mandibula: Origins and insertions**
Medial view of right hemimandible (inner surface).

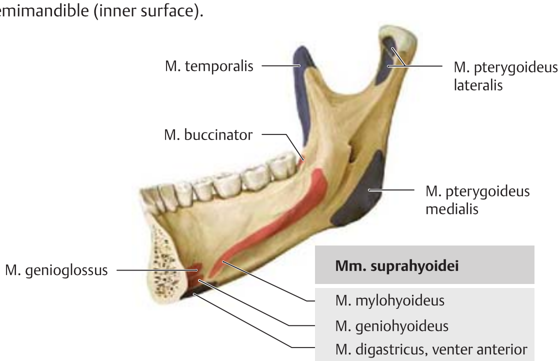


Fig. 30.5 **Skull base: Origins and insertions**
Inferior view of external skull.

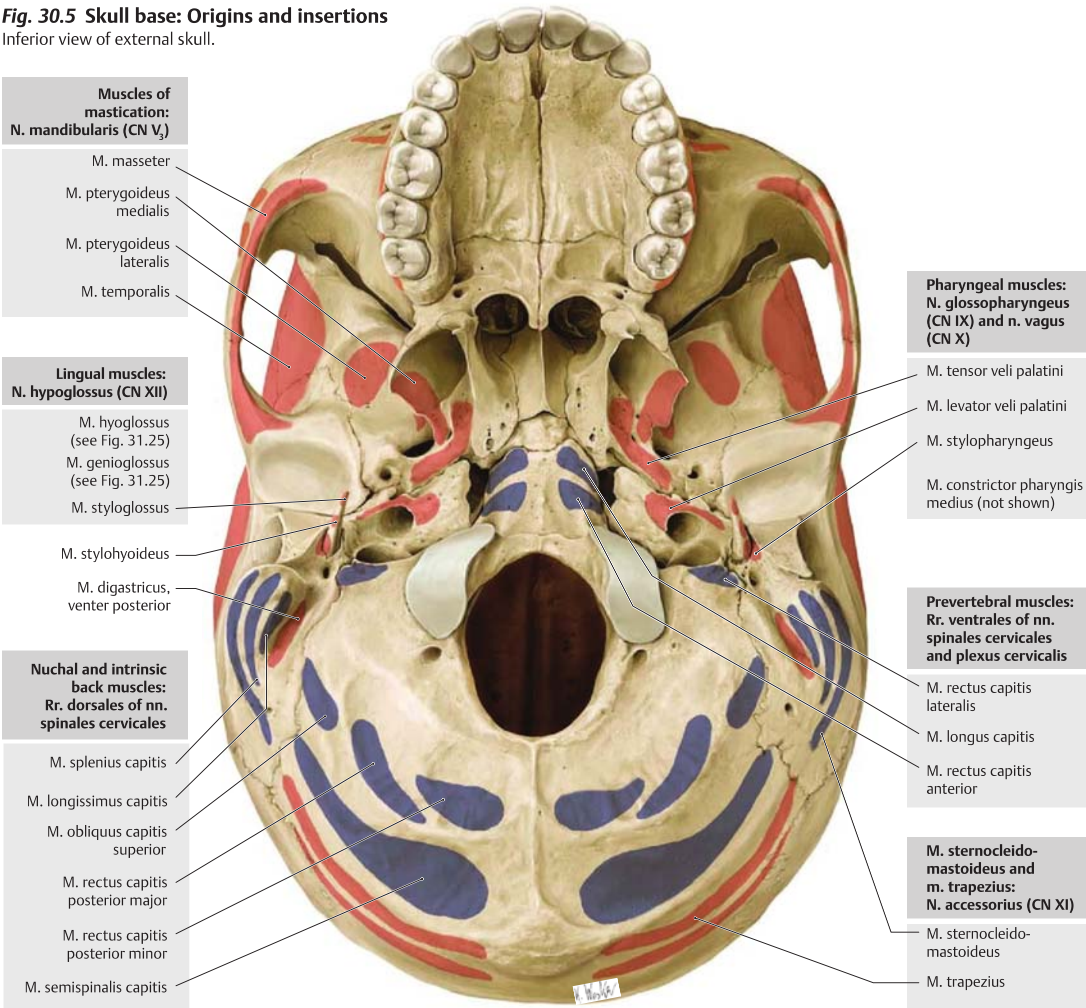
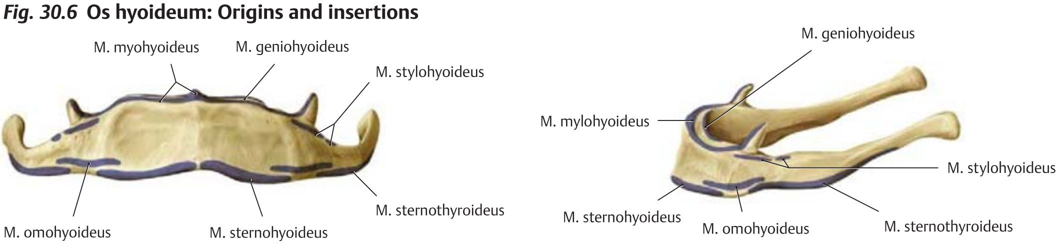


Fig. 30.6 **Os hyoideum: Origins and insertions**



A Anterior view.

B Oblique left lateral view.

Muscle Facts (I)

The muscles of facial expression originate on bone and/or fascia, and insert into the subcutaneous tissue of the face. This allows them to produce their effects by pulling on the skin.

Fig. 30.7 **M. occipitofrontalis**
Anterior view.

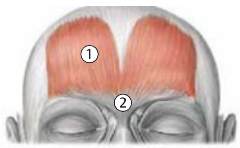
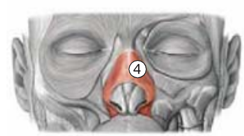
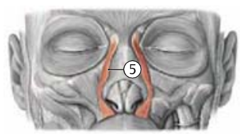


Fig. 30.8 **Muscles of the palpebral fissure and nose**
Anterior view.

A M. orbicularis oculi.



B M. nasalis.



C M. levator labii superioris alaeque nasi.

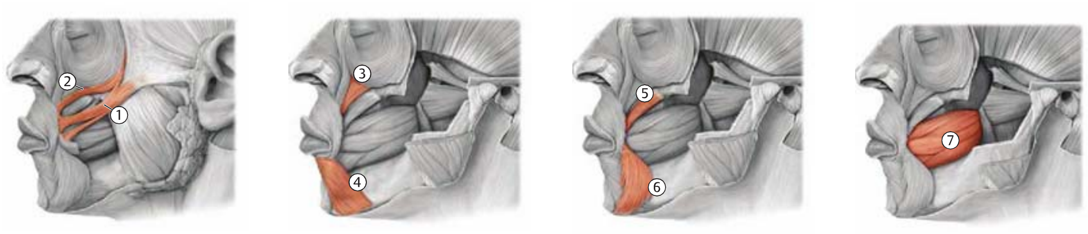
Fig. 30.9 **Muscles of the ear**
Left lateral view.

Table 30.1 **Muscles of facial expression: Forehead, nose, and ear**

Muscle	Origin	Insertion*	Main action(s)**
Calvaria			
① M. occipitofrontalis (venter frontalis)	Galea aponeurotica	Skin and subcutaneous tissue of eyebrows and forehead	Elevates eyebrows, wrinkles skin of forehead
Palpebral fissure and nose			
② M. procerus	Os nasale, cartilago nasi lateralis (upper part)	Skin of lower forehead between eyebrows	Pulls medial angle of eyebrows inferiorly, producing transverse wrinkles over bridge of nose
③ M. orbicularis oculi	Margo orbitalis medialis, lig. palpebrale mediale; os lacrimale	Skin around margo orbitalis, superior and inferior tarsal plates	Acts as orbital sphincter (closes eyelids) • Palpebral portion gently closes • Orbital portion tightly closes (as in winking)
④ M. nasalis	Maxilla (superior region of dens caninus)	Cartilago nasi	Flares nostrils by drawing ala (side) of nose toward nasal septum
⑤ M. levator labii superioris alaeque nasi	Maxilla (proc. frontalis)	Cartilago alaris major and labium superius	Elevates upper lip, opens nostril
Ear			
⑥ M. auricularis anterior	Fascia temporalis (anterior portion)	Spina helicis	Pull ear superiorly and anteriorly
⑦ M. auricularis superior	Galea aponeurotica	Upper portion of auricle	Elevate ear
⑧ M. auricularis posterior	Proc. mastoideus	Concha auriculae	Pull ear superiorly and posteriorly

*There are no bony insertions for the muscles of facial expression.
**All muscles of facial expression are innervated by the n. facialis (CN VII) via rr. temporales, rr. zygomatici, r. buccalis, r. marginalis mandibularis, or r. colli arising from the plexus parotideus (see p. 478).

Fig. 30.10 **Muscles of the mouth**
Left lateral view.



A Mm. zygomaticus major and minor.

B M. levator labii superioris and m. depressor labii inferioris.

C Mm. levator and depressor anguli oris.

D M. buccinator.

E M. orbicularis oris, anterior view.

F M. mentalis, anterior view.

Table 30.2 **Muscles of facial expression: Mouth and neck**

Muscle	Origin	Insertion*	Main action(s)**
Mouth			
① M. zygomaticus major	Os zygomaticum (facies lateralis, pars posterior)	Skin at angulus oris	Pulls corner of mouth superiorly and laterally
② M. zygomaticus minor		Labium superius medial to angulus oris	Pulls upper lip superiorly
M. levator labii superioris alaeque nasi (see Fig. 30.8C)	Maxilla (proc. frontalis)	Cartilago alaris major andlabium superius	Elevates upper lip, opens nostril
③ M. levator labii superioris	Maxilla (proc. frontalis) and regio infraorbitalis	Skin of labium superius, cartilago alaris major	Elevates upper lip, dilates nostril, raises angle of the mouth
④ M. depressor labii inferioris	Mandibula (anterior portion linea obliqua)	Labium inferius at midline; blends with muscle from opposite side	Pulls lower lip inferiorly and laterally
⑤ M. levator anguli oris	Maxilla (below foramen infraorbitale)	Skin at angulus oris	Raises angle of mouth, helps form nasolabial furrow
⑥ M. depressor anguli oris	Mandibula (fossa canina corporis maxillae, dens premolaris I, and dens molaris I)	Skin at angulus oris, Cartilago alaris major; blends with m. orbicularis oris	Pulls angle of mouth inferiorly and laterally
⑦ M. buccinator	Mandibula, procc. alveolares of maxilla and mandibula, raphe pterygomandibularis	Angulus oris, m. orbicularis oris	Presses cheek against molar teeth, working with tongue to keep food between occlusal surfaces and out of oral vestibule; expels air from oral cavity/resists distension when blowing *Unilateral:* Draws mouth to one side
⑧ M. orbicularis oris	Deep surface of skin Superiorly: maxilla (median plane) Inferiorly: mandibula	Mucous membrane of lips	Acts as oral sphincter • Compresses and protrudes lips (e.g., when whistling, sucking, and kissing) • Resists distension (when blowing)
M. risorius (see p. 462)	Fascia parotidea	Skin at angulus oris	Retracts corner of mouth as in grimacing
⑨ M. mentalis	Mandibula (incisive fossa)	Skin of mentum	Elevates and protrudes lower lip
Neck			
Platysma (see p. 463)	Skin over lower neck and upper lateral thorax	Mandibula (inferior border), skin over lower face, angulus oris	Depresses and wrinkles skin of lower face and mouth; tenses skin of neck; aids in forced depression of the mandibula

*There are no bony insertions for the muscles of facial expression.
**All muscles of facial expression are innervated by the n. facialis (CN VII) via rr. temporales, rr. zygomatici, rr. buccales, rr. mandibulares or rr. cervicales arising from plexus parotideus.

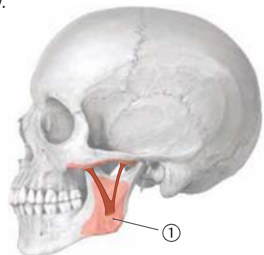
Muscle Facts (II)

The muscles of mastication are located at various depths in the parotid and infratemporal regions of the face. They attach to mandibula and receive their motor innervation from n. mandibularis of n. trigeminus (CN V_3). The muscles of the oral floor that aid in opening the mouth are found on p. 562.

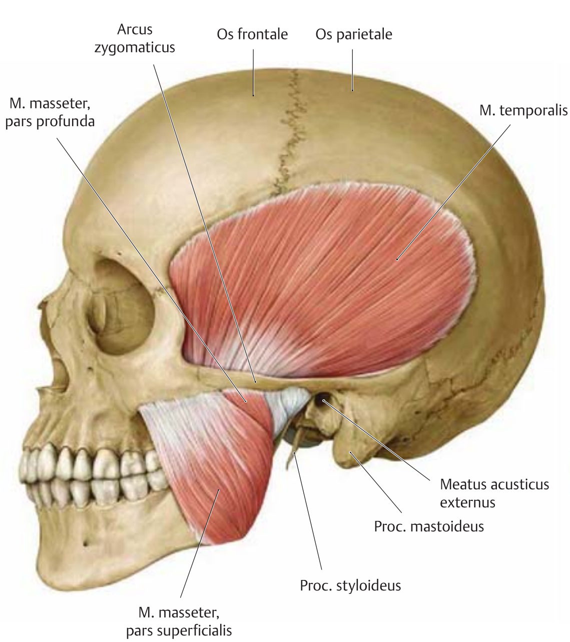
Table 30.3 Muscles of mastication: Masseter and temporalis

Muscle	Origin	Insertion	Innervation	Action
① M. masseter	Pars superficialis: Arcus zygomaticus (anterior two thirds) Pars profunda: Arcus zygomaticus (posterior one third)	Angulus mandibulae (tuberositas masseterica)	N. mandibularis (CN V_3) via n. massetericus	Elevates (adducts) and protrudes mandibula
② M. temporalis	Linea temporalis	Proc. coronoideus mandibulae (apex and facies medialis)	N. mandibularis (CN V_3) via nn. temporalis profundi.	*Vertical fibers:* Elevate (adduct) mandibula *Horizontal fibers:* Retract (retrude) mandibula *Unilateral:* Lateral movement of mandibula (chewing)

Fig. 30.11 **M. masseter**
Left lateral view.

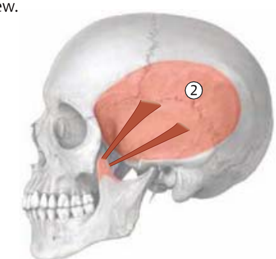


A Schematic.

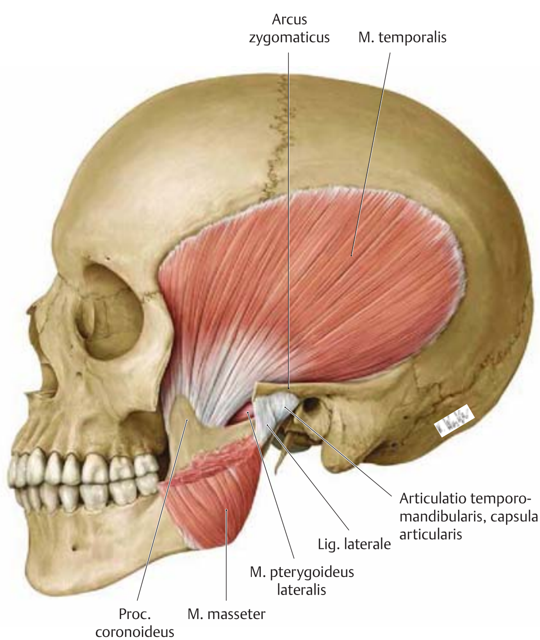


B M. masseter and m. temporalis.

Fig. 30.12 **M. temporalis**
Left lateral view.



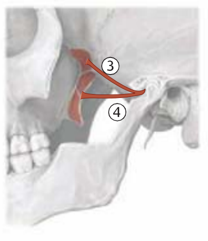
A Schematic.



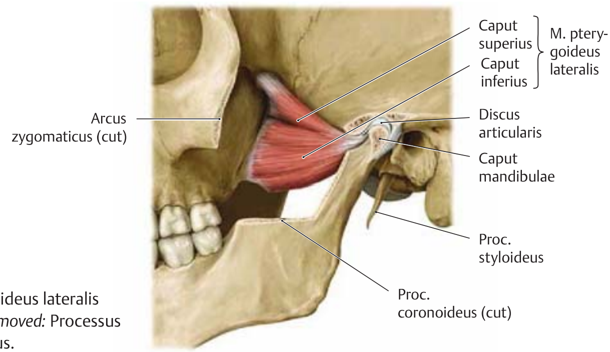
B M. temporalis. *Removed:* M. masseter and arcus zygomaticus.

Table 30.4	Muscles of mastication: Pterygoid muscles				
Muscle		**Origin**	**Insertion**	**Innervation**	**Action**
M. pterygoideus lateralis	③ Pars superior	Crista infratemporalis ossis sphenoidalis	Articulatio temporomandibularis (disus articularis)	N. mandibularis (CN V_3) via n. pterygoideus lateralis	*Bilateral:* Protrudes mandibula (pulls articular disk forward) *Unilateral:* Lateral movements of mandibula (chewing)
	④ Pars inferior	Lamina lateralis of proc. pterygoideus (lateral surface)	Mandibula (proc. condylaris)		
M. pterygoideus medialis	⑤ Pars superficialis	Tuber maxillae	Tuberositas pterygoidea on medial surface of the angulus mandibulae	N. mandibularis (CN V_3) via n. pterygoideus medialis	Elevates (adducts) mandibula
	⑥ Pars profunda	Medial surface of lamina lateralis of proc. pterygoideus and fossa pterygoidea			

Fig. 30.13 **M. pterygoideus lateralis**
Left lateral view.

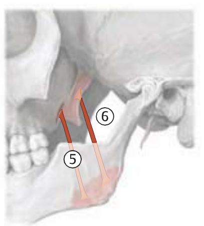


A Schematic.

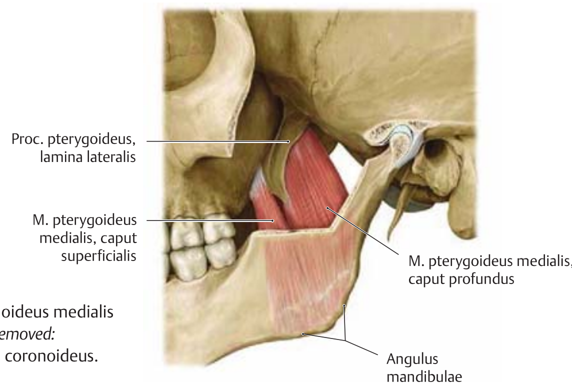


B M. pterygoideus lateralis sinister. *Removed:* Processus coronoideus.

Fig. 30.14 **M. pterygoideus medialis**
Left lateral view.

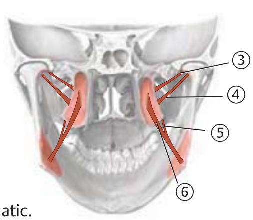


A Schematic.

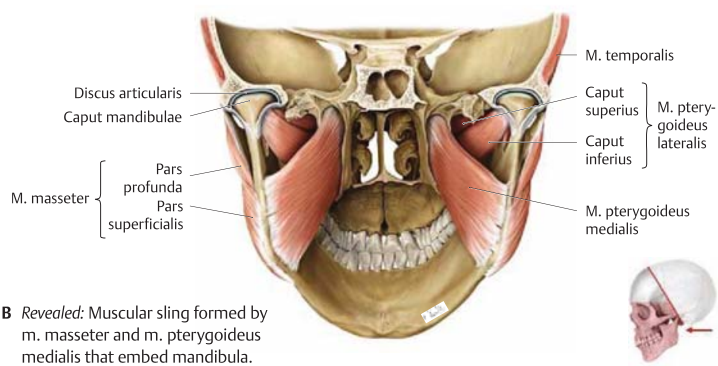


B M. pterygoideus medialis sinister. *Removed:* Processus coronoideus.

Fig. 30.15 **Masticatory muscle sling**
Oblique posterior view.



A Schematic.

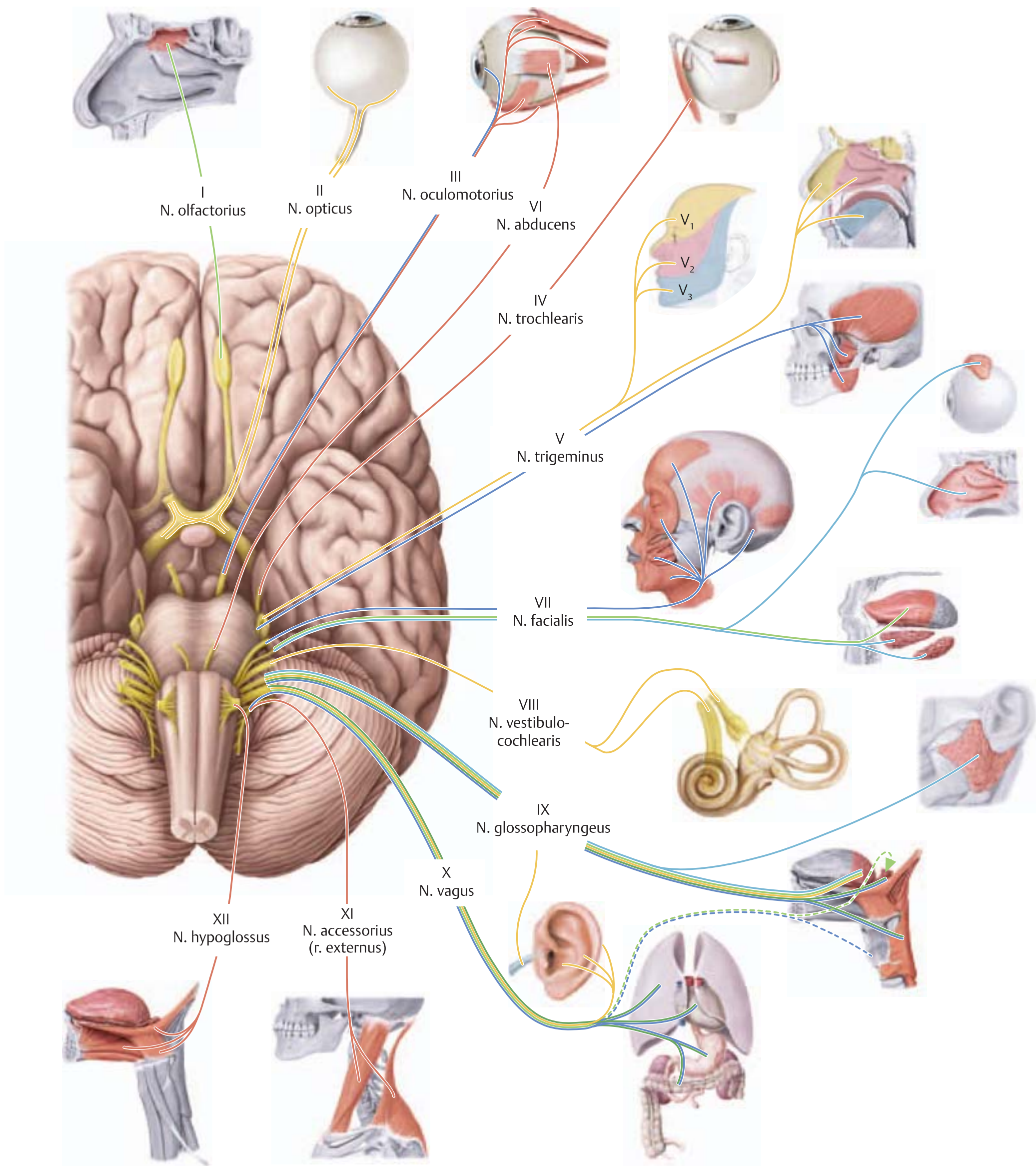


B *Revealed:* Muscular sling formed by m. masseter and m. pterygoideus medialis that embed mandibula.

Cranial Nerves: Overview

Fig. 31.1 **Cranial nerves**

Inferior (basal) view. The 12 pairs of cranial nerves (CN) are numbered according to the order of their emergence from the brainstem. *Note:* The sensory and motor fibers of the cranial nerves enter and exit the brainstem at the same sites (in contrast to spinal nerves, whose sensory and motor fibers enter and leave through posterior and anterior roots, respectively).



The cranial nerves contain both afferent (sensory) and efferent (motor) axons that belong to either the somatic or the autonomic (visceral) nervous system (see pp. 622–623). The somatic fibers allow interaction with the environment, whereas the visceral fibers regulate the autonomic activity of internal organs. In addition to the general fiber types, the cranial nerves may contain special fiber types associated with particular structures (e.g., auditory apparatus and taste buds). The cranial nerve fibers originate or terminate at specific nuclei, which are similarly classified as either general or special, somatic or visceral, and afferent or efferent.

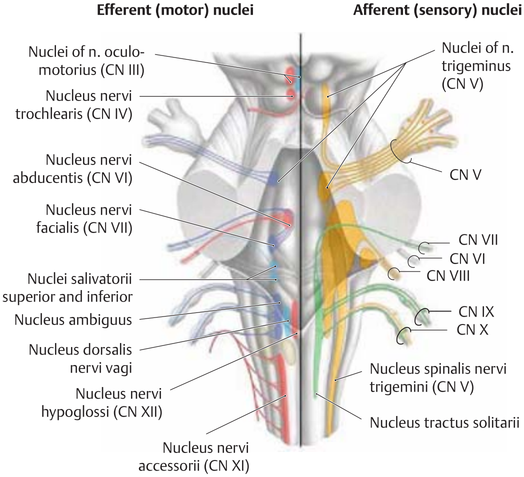
Table 31.1 Classification of cranial nerve fibers and nuclei

This color coding is used in subsequent chapters to indicate fiber and nuclei classifications.

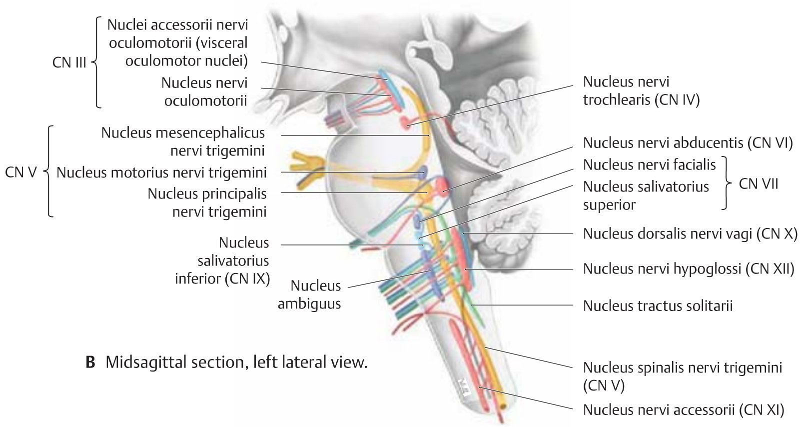
Color	Fiber type	Example	Color	Fiber type	Example
(red)	General somatic efferent (somatomotor function)	Innervate skeletal muscles	(gold)	General somatic afferent (somatic sensation)	Conduct impulses from skin, skeletal muscle spindles
(blue)	General visceral efferent (visceromotor function)	Innervate smooth muscle of the viscera, intraocular muscles, heart, glandulae salivariae, etc.	(gold)	Special somatic afferent	Conduct impulses from retina, auditory and vestibular apparatuses
(violet)	Special visceral efferent	Innervate skeletal and cardiac muscle derived from branchial arches	(dark green)	General visceral afferent (visceral sensation)	Conduct impulses from viscera, blood vessels
			(light green)	Special visceral afferent	Conduct impulses from taste buds, olfactory mucosa

***Fig. 31.2* Cranial nerve nuclei**

The sensory and motor fibers of cranial nerves III to XII originate and terminate in the brainstem at specific nuclei.



A Posterior view with the cerebellum removed.



B Midsagittal section, left lateral view.

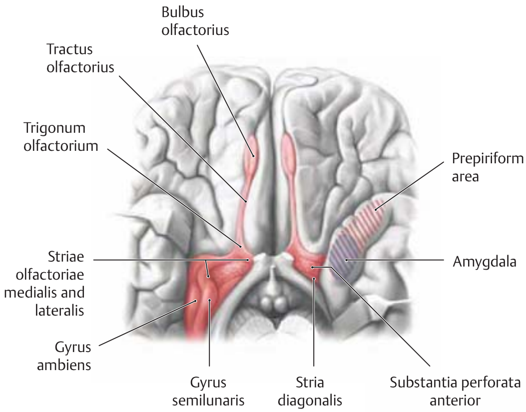
Table 31.2 Cranial nerves

Cranial nerve	Origin	Functional fiber types
CN I: N. olfactorius	Telencephalon*	(light green)
CN II: N. opticus	Diencephalon*	(gold)
CN III: N. oculomotorius	Mesencephalon	(blue), (red)
CN IV: N. trochlearis		(red)
CN V: N. trigeminus	Pons	(violet), (gold)
CN VI: N. abducens		(red)
CN VII: N. facialis		(violet), (blue), (light green), (gold)
CN VIII: N. vestibulocochlearis	Medulla oblongata	(gold)
CN IX: N. glossopharyngeus		(violet), (blue), (light green), (dark green), (gold)
CN X: N. vagus		(violet), (blue), (light green), (dark green), (gold)
CN XI: N. accessorius		(violet), (red)
CN XII: N. hypoglossus		(red)

* The n. olfactorius and nn. optici are extensions of the brain rather than true nerves; they are therefore not associated with nuclei in the brainstem.

CN I & II: N. Olfactorius & N. Opticus

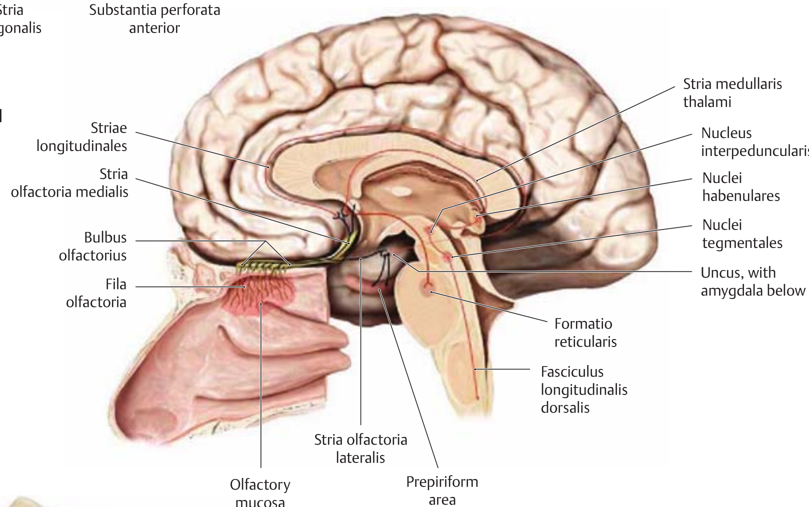
The n. olfactorius and n. opticus are not true peripheral nerves, but extensions (tracts) of the telencephalon and diencephalon, respectively. They are therefore not associated with cranial nerve nuclei in the brainstem.



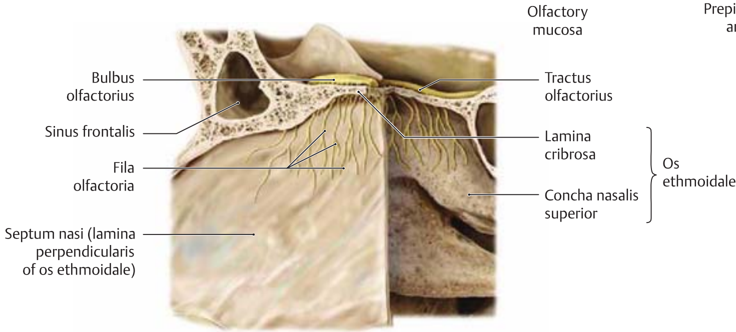
A Bulbus and tractus olfactorius, inferior view. *Note:* The amygdala and prepiriform area are deep to the basal surface of the brain.

Fig. 31.3 N. olfactorius (CN I)

Fiber bundles in the olfactory mucosa pass from the nasal cavity through lamina cribrosa of os ethmoidale into fossa cranii anterior, where they synapse in bulbus olfactorius. Axons from second-order afferent neurons in bulbus olfactorius pass through tractus olfactorius and striae olfactoria medialis or lateralis, terminating in the cerebral cortex of the prepiriform area, in the amygdala, or in neighboring areas. See p. 617 for the mechanisms of smell.



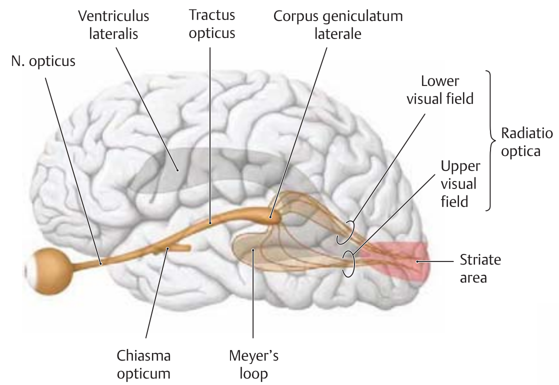
B Course of n. olfactorius (fila olfactoria). Parasagittal section, viewed from left side.



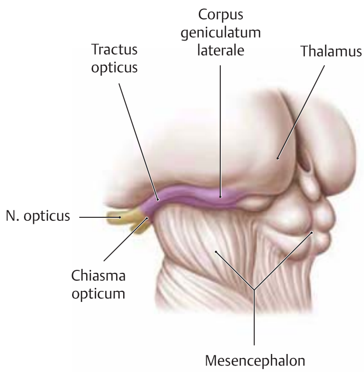
C Fila olfactoria. Portion of left nasal septum and lateral wall of right nasal cavity, left lateral view.

Fig. 31.4 N. opticus (CN II)

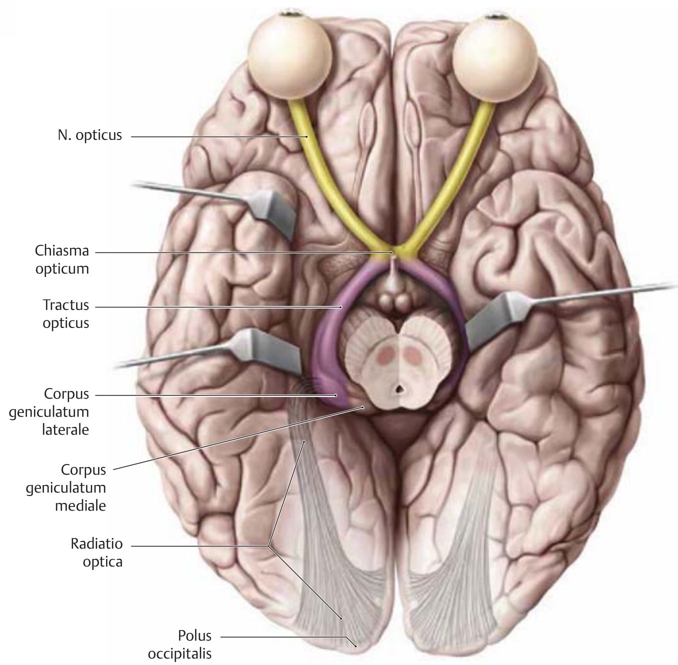
The n. opticus passes from the eyeball through canalis opticus into the fossa cranii media. The two optic nerves join below the base of the diencephalon to form the chiasma opticum, before dividing into the left and right tractus opticus. Each of these tracts divides into a lateral and medial root. Many retinal cell ganglion axons cross the midline to the contralateral side of the brain in the optic chiasm. See p. 619 for the mechanisms of sight.



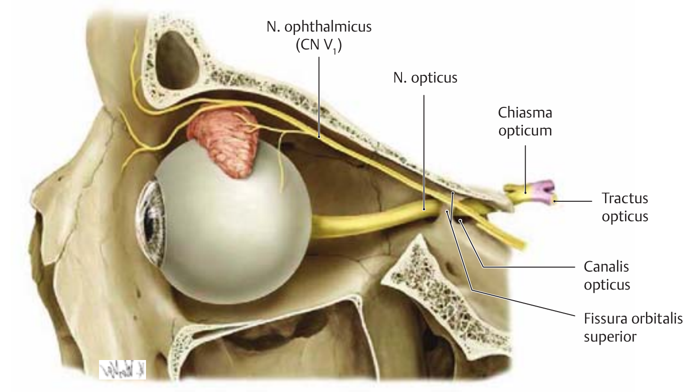
A N. opticus in the geniculate visual pathway, left lateral view.



B Termination of tractus opticus, left postero-lateral view of the brainstem. The n. opticus contains the axons of retinal ganglion cells, which terminate mainly in the corpus geniculatum laterale of the diencephalon and in the mesencephalon (colliculus superior).



C Course of n. opticus, inferior (basal) view.



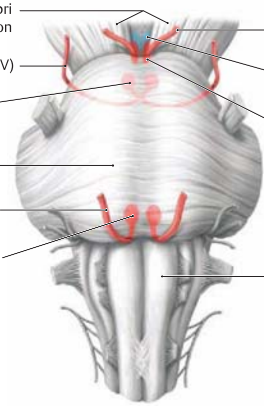
D N. opticus in the left orbita, lateral view. The n. opticus exits the orbita via the canalis opticus. *Note:* The other cranial nerves entering the orbita do so via fissura orbitalis superior.

CN III, IV & VI: N. Oculomotorius, N. Trochlearis & N. Abducens

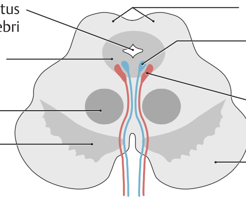
Cranial nerves III, IV, and VI innervate the extraocular muscles (see p. 509). Of the three, only n. oculomotorius (CN III) contains both somatic and visceral efferent fibers; it is also the only cranial nerve of the extraocular muscles to innervate multiple extra- and intraocular muscles.

Fig. 31.5 Nuclei of n. oculomotorius, n. trochlearis, and n. abducens

The n. trochlearis (CN IV) is the only cranial nerve in which all the fibers cross to the opposite side. It is also the only cranial nerve to emerge from the dorsal side of the brainstem and, consequently, has the longest intradural (intracranial) course of any cranial nerve.



A Emergence of the cranial nerves of the extraocular muscles. Anterior view of the brainstem.



B Nuclei of n. oculomotorius. Transverse section, superior view.

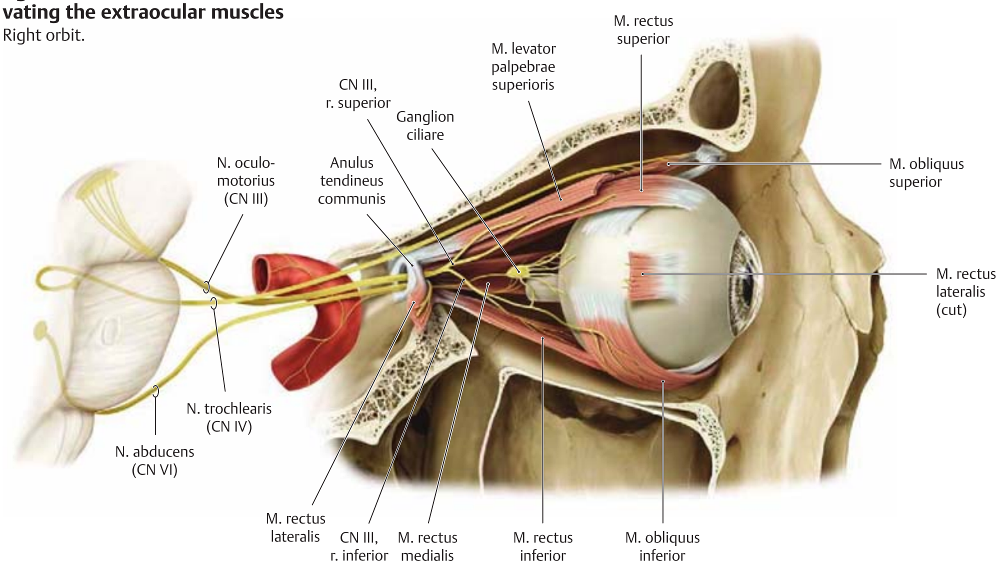
Table 31.3 Cranial nerves of the extraocular muscles

Course*	Fibers	Nuclei	Function	Effects of nerve injury
N. oculomotorius (CN III)				
Runs anteriorly from mesencephalon	Somatic efferent	Nucl. nervi oculomotorius	Innervates: • M. levator palpebrae sup. • M. rectus med., sup., and inf. • M. obliquus inf.	Complete oculomotor palsy (paralysis of extra- and intraocular muscles): • Ptosis (drooping of eyelid) • Downward and lateral gaze deviation • Diplopia (double vision) • Mydriasis (pupil dilation) • Accommodation difficulties (ciliary paralysis)
	Visceral efferent	Nuclei accessorii nervi oculomotorii (Edinger-Westphal)	Synapse with neurons of ganglion ciliare. Innervates: • M. spincter pupillae • M. ciliaris	
N. trochlearis (CN IV)				
Emerges from posterior surface of brainstem near midline, courses anteriorly around the pedunculus cerebri	Somatic efferent	Nucl. nervi trochlearis	Innervates: • M. obliquus sup.	• Diplopia • Affected eye is higher and deviated medially (dominance of inferior oblique)
N. abducens (CN VI)				
Follows a long extradural path**	Somatic efferent	Nucleus nervi abducentis	Innervates: • M. rectus lateralis	• Diplopia • Affected eye is deviated superiorly

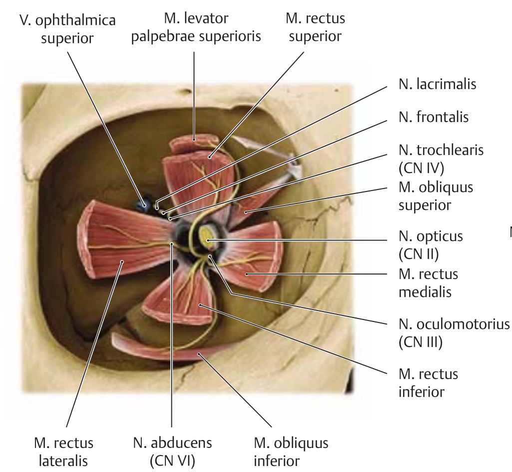
* All three nerves enter the orbita through the fissura orbitalis superior; CN III and CN VI pass through the anulus tendineus communis of the extraocular muscles.
** The n. abducens follows an extradural course; n. abducens palsy may therefore develop in association with meningitis and subarachnoid hemorrhage.

Note: The n. oculomotorius supplies parasympathetic innervation to the intraocular muscles and somatic motor innervation to most of the extraocular muscles (also m. levator palpebrae superioris). Its parasympathetic fibers synapse in ganglion ciliare. Oculomotor nerve palsy may affect exclusively the parasympathetic or somatic fibers, or both concurrently.

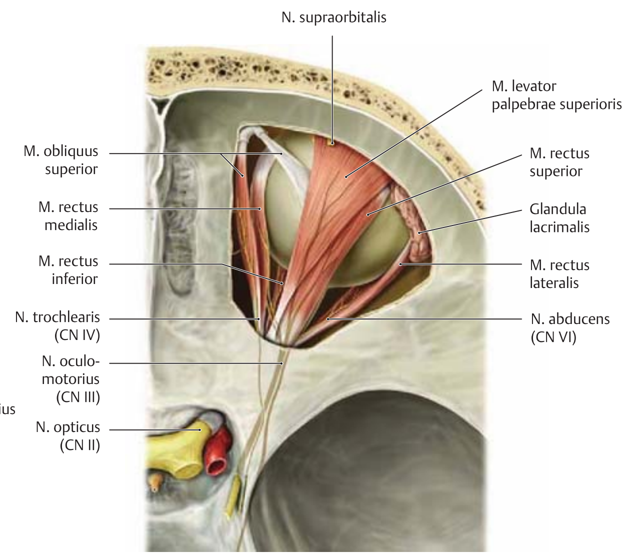
Fig. 31.6 **Course of the nerves innervating the extraocular muscles**
Right orbit.



A Lateral view.



B Anterior view. CN II exits the orbit via canalis opticus, which lies medial to fissura orbitalis superior (site of emergence of CN III, IV, and VI).



C Superior view of the opened orbit. Note the relationship between canalis opticus and fissura orbitalis superior.

CN V: N. Trigeminus

N. trigeminus, the sensory nerve of the head, has three somatic afferent nuclei: the nucleus mesencephalicus, which receives proprioceptive fibers from the muscles of mastication; the nucleus principalis, which chiefly mediates touch; and the nucleus spinalis, which mediates pain and temperature sensation. The nucleus motorius supplies motor innervation to the muscles of mastication.

Fig. 31.7 **Nuclei of n. trigeminus**

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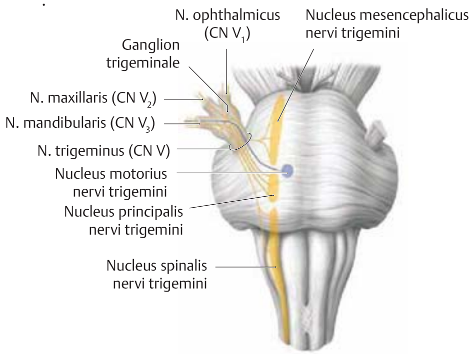
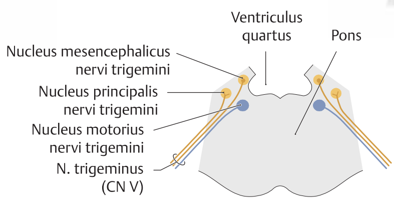


A Anterior view of the brainstem.



B Cross section through pons, superior view.

Fig. 31.8 **Divisions of n. trigeminus (CN V)**

Right lateral view.

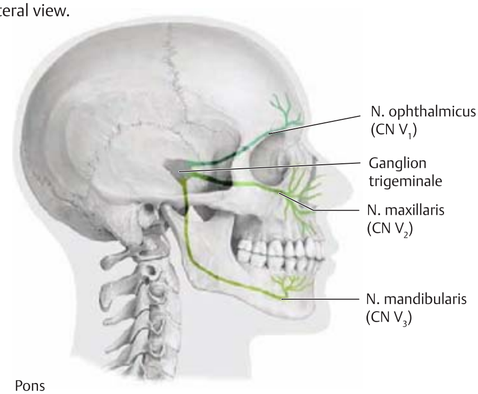
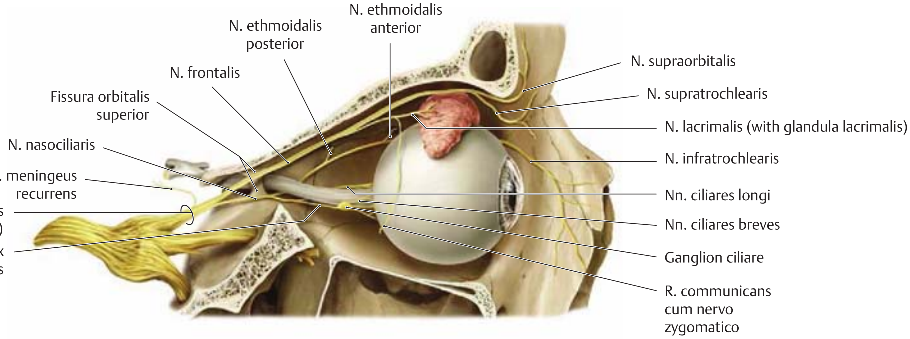


Table 31.4 **N. trigeminus (CN V)**

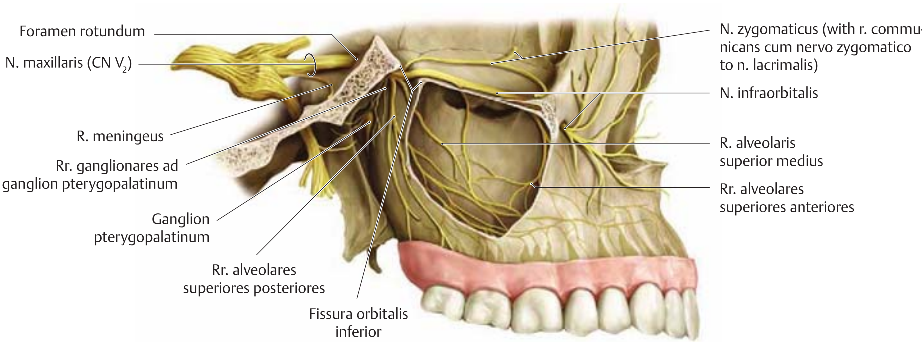
Course	Fibers	Nuclei	Function	Effects of nerve injury
Exits from Fossa cranii media. **N. ophthalmicus (CN V_1):** Enters orbita through fissura orbitalis superior **N. maxillaris (CN V_2):** Enters fossa pterygopalatina through foramen rotundum **N. mandibularis (CN V_3):** Passes through foramen ovale to inferior surface of basis cranii	Somatic afferent	• Nucl. principalis nervi trigemini (pons) • Nucl. mesencephalicus nervi trigemini • Nucl. spinalis nervi trigemini	Innervates: • Facial skin (**A**) • Nasopharyngeal mucosa (**B**) • Tongue (anterior two thirds) (**C**) Involved in the corneal reflex (reflex closure of eyelid)	• Sensory loss (traumatic nerve lesions) • Herpes zoster ophthalmicus (varicella-zoster virus); herpes zoster of the face
	Special visceral efferent	Nucl. motorius nervi trigemini	Innervates (via CN V_3): • Muscles of mastication (m. temporalis, m. masseter, m. pterygoideus lat. and med. (**D**)) • Oral floor muscles (m. mylohyoideus, m. digastricus (venter anterior)) • M. tensor tympani • M. tensor veli palatini	
	Visceral efferent pathway*	• N. lacrimalis (CN V_1) conveys parasympathetic fibers from CN VII along the n. zygomaticus (CNV_2) to the Glandula lacrimalis • N. lingualis (CN V_3) conveys parasympathetic fibers from CN VII (via the chorda tympani) to glandula submandibularis and glandula sublingualis • N. auriculotemporalis (CN V_3) conveys parasympathetic fibers from CN IX to glandula parotidea		
	Visceral afferent pathway*	Gustatory (taste) fibers from CN VII (via chorda tympani) travel with n. ligualis (CNV_3) to the anterior two thirds of the tongue		

* Fibers of certain cranial nerves adhere to divisions or branches of the n. trigeminus, by which they travel to their destination.

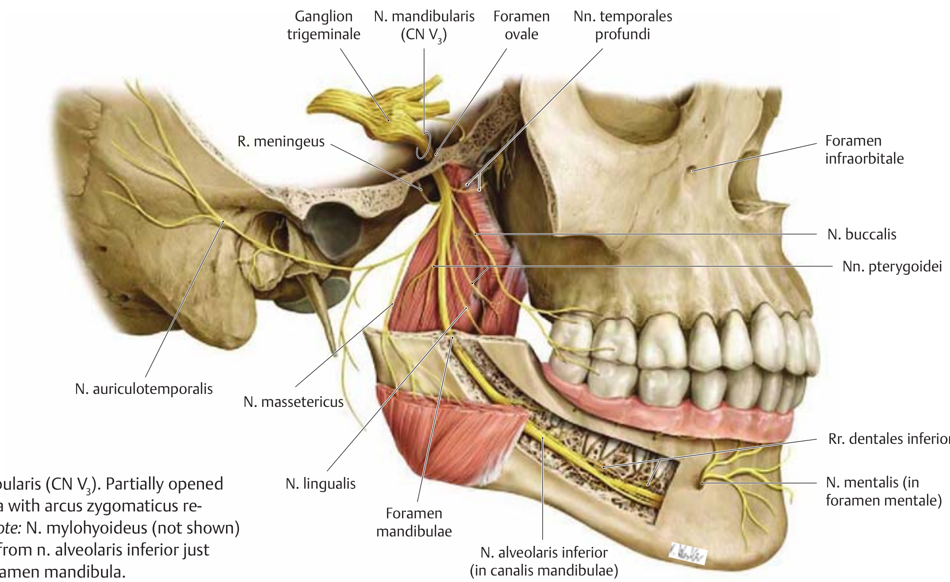
Fig. 31.9 Course of the trigeminal nerve divisions
Right lateral view.



A N. ophthalmicus (CN V_1). Partially opened right orbita.



B N. maxillaris (CN V_2). Partially opened right sinus maxillaris with arcus zygomaticus removed.

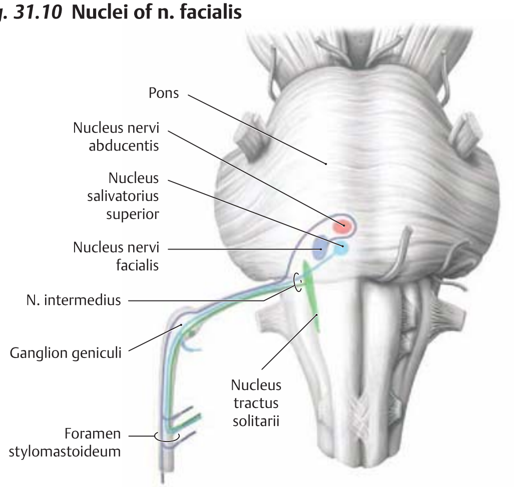


C N. mandibularis (CN V_3). Partially opened mandibula with arcus zygomaticus removed. *Note:* N. mylohyoideus (not shown) branches from n. alveolaris inferior just before foramen mandibula.

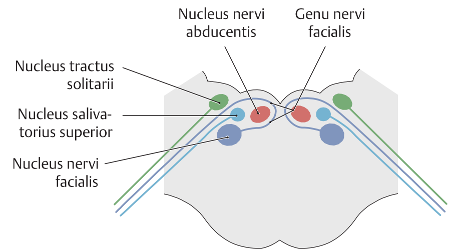
CN VII: N. Facialis

N. facialis mainly conveys special visceral efferent (branchiogenic) fibers from nucleus nervi facialis to the muscles of facial expression. The other visceral efferent (parasympathetic) fibers from nucleus salivatorius superior are grouped with the visceral afferent (gustatory) fibers to form n. intermedius.

Fig. 31.10 Nuclei of n. facialis



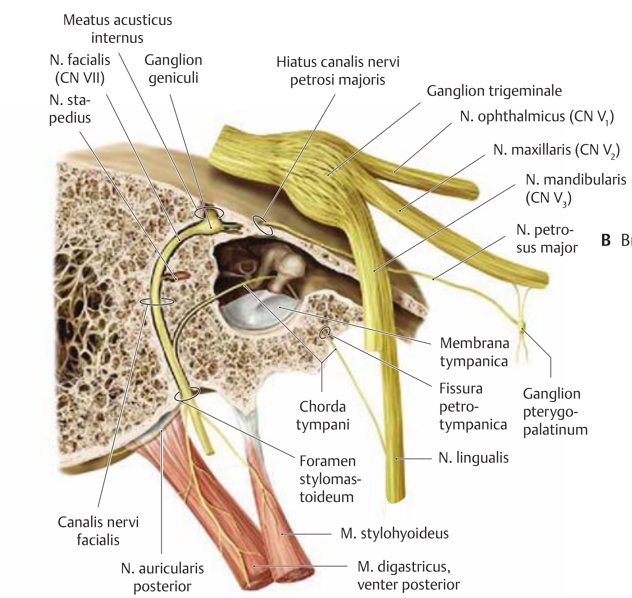
A Anterior view of the brainstem.



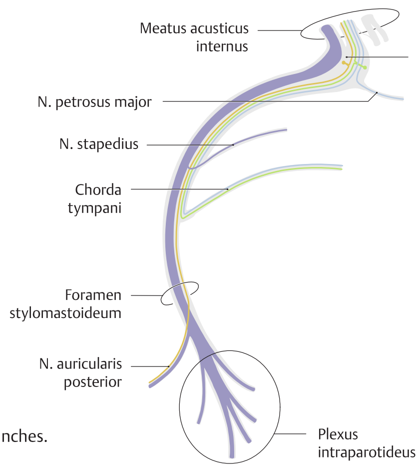
B Cross section through pons, superior view.

Fig. 31.11 Branches of n. facialis

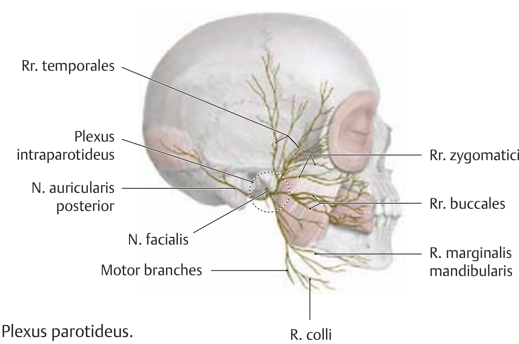
Right lateral view.



A N. facialis in os temporale.



B Branches.



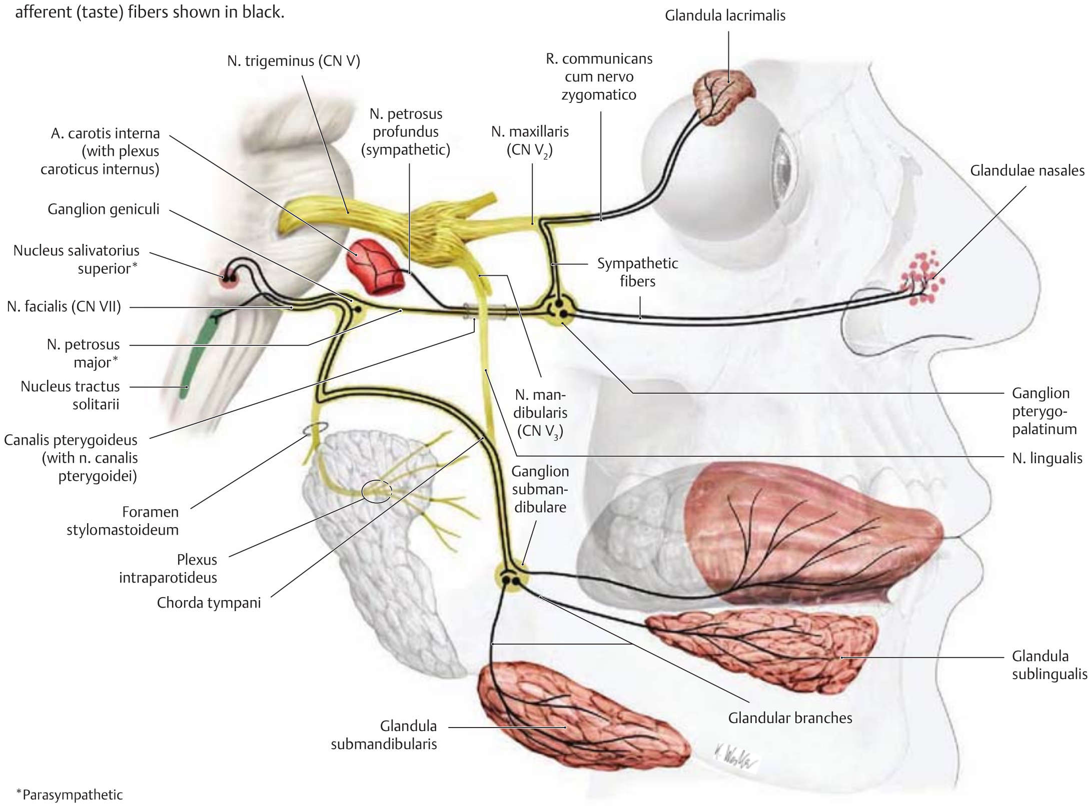
C Plexus parotideus.

Table 31.5 N. facialis (CN VII)

Course	Fibers	Nuclei	Function	Effects of nerve injury
Emerges in the cerebellopontine angle between the pons and olive; passes through the meatus acusticus internus into the os temporale (pars petrosa), where it divides into: • N. petrosus major • N. stapedius • Chorda tympani Certain visceral efferent fibers pass through the foramen stylomastoideum to the basis cranii, forming the plexus intraparotideus	Special visceral efferent	Nucl. nervi facialis	Innervate: • Muscles of facial expression • M. stylohyoideus • M. diagastricus (venter posterior) • M. stapedius	Peripheral facial nerve injury: paralysis of muscles of facial expression on affected side Associated disturbances of taste, lacrimation, salivation, etc.
	Visceral efferent (parasympathetic)*	Nucl. salivatorius superior	Synapse with neurons in the Ganglion pterygopalatinum or Ganglion submandibulare. Innervate: • Glandula lacrimalis • Glandulae nasales minores • Glandulae palatinae • Glandula submandibularis • Glandula sublingualis • Glandulae salivariae minores of tongue (dorsum)	
	Special visceral afferent*	Nuclei tractus solitarii	Peripheral processes of fibers from Ganglion geniculi form the chorda tympani (gustatory fibers from tongue)	
	Somatic afferent	Sensory fibers from the auricle, skin of the meatus acusticus externus, and outer surface of the membrana tympanica travel via CN VII to the nucl. principalis nervi trigemini		

* Grouped to form n. intermedius, which aggregates with the visceral efferent fibers from the nucl. nervi facialis.

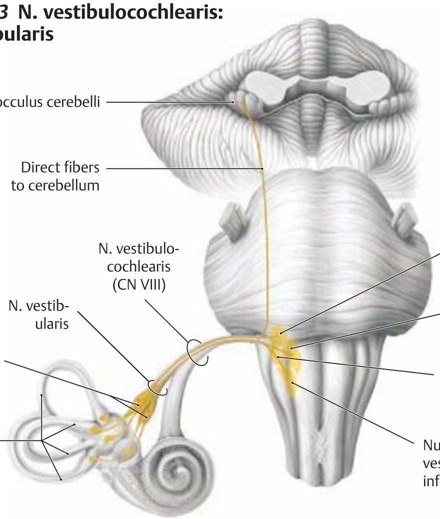
***Fig. 31.12* Course of n. facialis**
Right lateral view. Visceral efferent (parasympathetic) and special visceral afferent (taste) fibers shown in black.



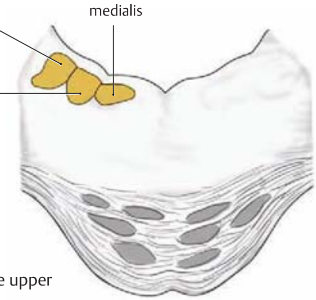
CN VIII: N. Vestibulocochlearis

N. vestibulocochlearis is a special somatic afferent nerve that consists of two roots. The n. vestibularis transmits impulses from the vestibular apparatus (balance, see p. 618); the n. cochlearis transmits impulses from the auditory apparatus (hearing, see p. 616).

Fig. 31.13 **N. vestibulocochlearis: N. vestibularis**

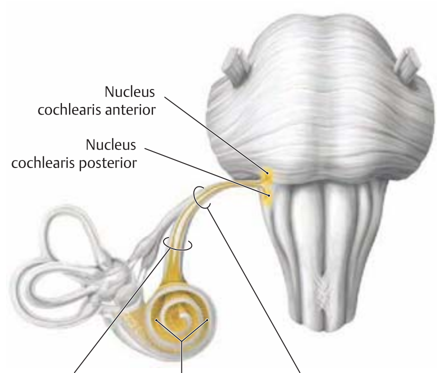


A Anterior view of medulla oblongata and pons with cerebellum.



B Cross section through the upper medulla oblongata.

Fig. 31.14 **N. vestibulocochlearis: N. cochlearis**



A Anterior view of medulla oblongata and pons.

B Cross section through the upper medulla oblongata.

Table 31.6 **N. vestibulocochlearis (CN VIII)**

Part	Course	Fibers	Nuclei	Function	Effects of nerve injury
Pars vestibularis	Pass from the inner ear through the meatus acusticus internus to the cerebellopontine angle, where they enter the brain	Special somatic afferent	Nucl. vestibularis sup., med., lat., and inf.	Peripheral processes from the canalis semicircularis, sacculus, and utriculus pass to the ganglion vestibulare and then to the four nuclei vestibulares	Dizziness
Pars cochlearis			Nucl. cochlearis posterior and anterior	Peripheral processes beginning at the hair cells of the organ of corti pass to the ganglion spirale and then to the two nuclei cochleares	Hearing loss

***Fig. 31.15* Ganglion vestibulare and ganglion cochleare (spirale cochleae)**
Note: The nn. vestibularis and cochlearis are still separate structures in pars petrosa of os temporale.

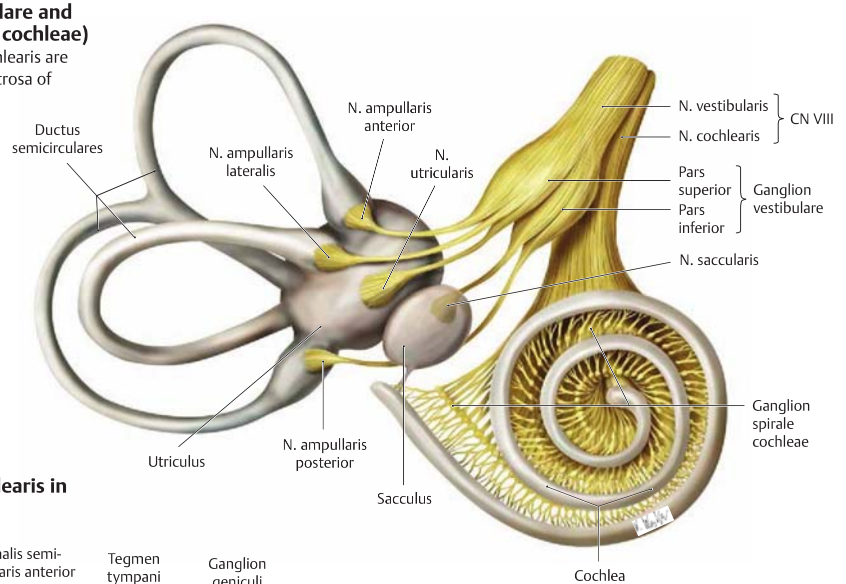
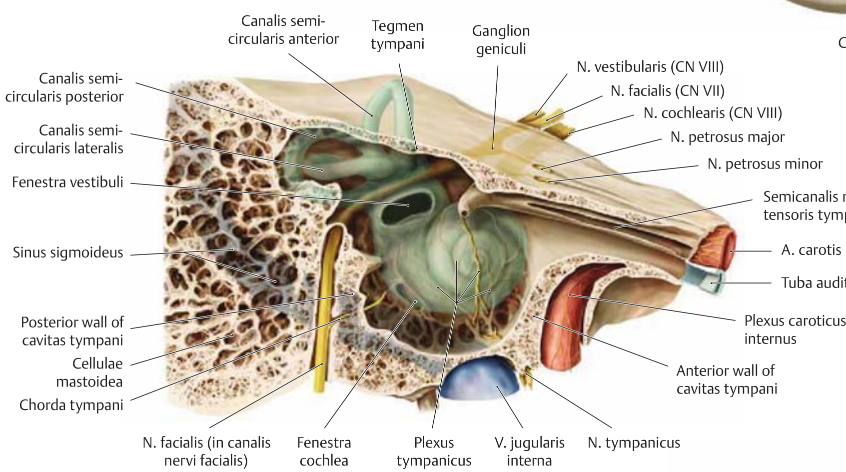
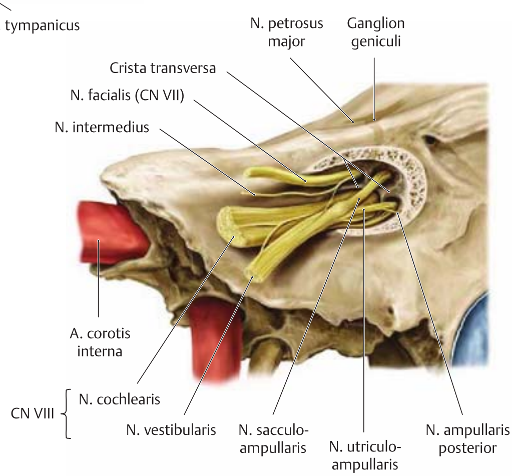


***Fig. 31.16* N. vestibulocochlearis in os temporale**



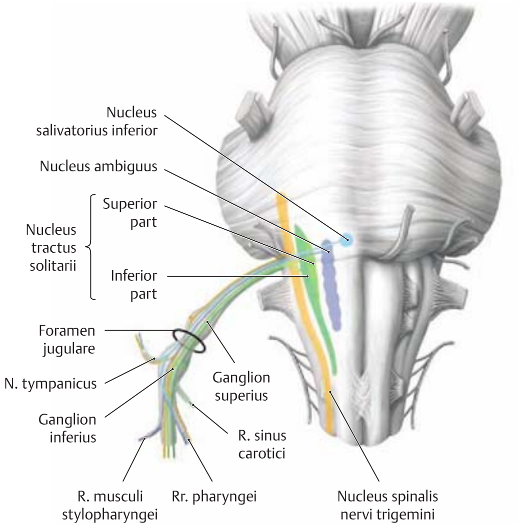
A Medial wall of cavitas tympani, oblique sagittal section.



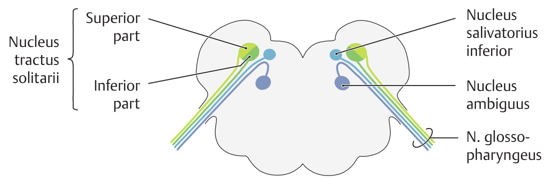
B Cranial nerves in meatus acusticus internus. Posterior oblique view of the right meatus.

CN IX: N. Glossopharyngeus

Fig. 31.17 **Nuclei of n. glossopharyngeus**



A Anterior view of medulla oblongata.



B Cross section through medulla oblongata, superior view. *Not shown:* Nuclei of n. trigeminus.

Fig. 31.18 **Course of n. glossopharyngeus**

Left lateral view. *Note:* Fibers from n. vagus (CN X) combine with fibers from CN IX to form the plexus pharyngeus and supply the sinus caroticus.

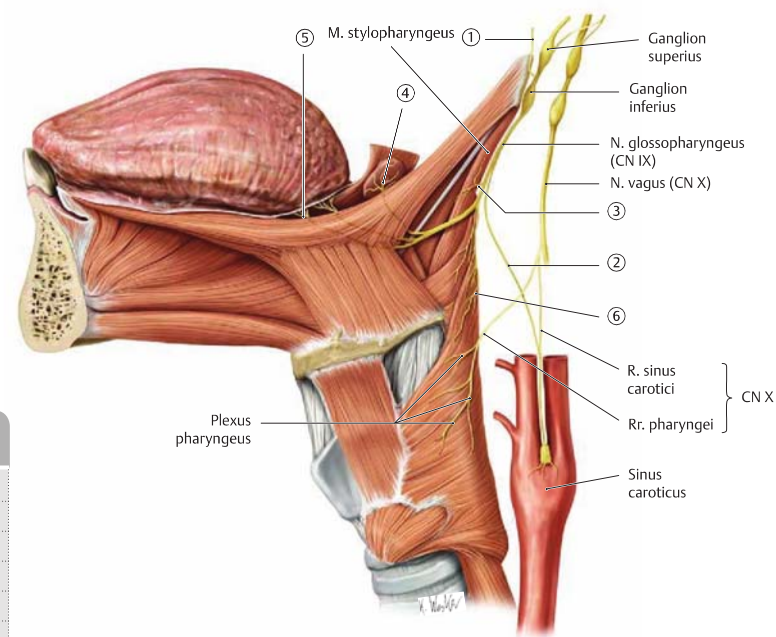


Table 31.7	Glossopharyngeal nerve branches
①	N. tympanicus
②	R. sinus carotici
③	R. musculi stylopharyngei
④	Rr. tonsillares
⑤	Rr. linguales
⑥	Rr. pharyngeales

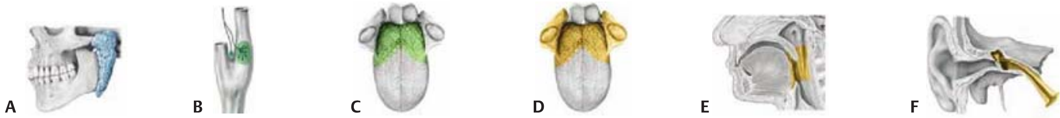


Table 31.8 N. glossopharyngeus (CN IX)

Course	Fibers	Nuclei	Function	Effects of nerve injury
Emerges from the medulla oblongata; leaves cavitas cranii through the foramen jugulare	Visceral efferent (parasympathetic)	Nucl. salivatorius inf.	Parasympathetic presynaptic fibers are sent to the ganglion oticum; postsynaptic fibers are distributed to • Glandula parotidea (**A**) • Glandulae buccales • Glandulae labiales	Isolated lesions of CN IX are rare. Lesions are generally accompanied by lesions of CN X and CN XI (cranial part), as all three emerge jointly from the foramen jugulare and are susceptible to injury in basal skull fractures.
	Special visceral efferent (branchiogenic)	Nucl. ambiguus	Innervate: • Constrictor muscles of the pharynx (rr. pharyngeales join with the n. vagus to form the plexus pharyngeus) • M. stylopharyngeus	
	Visceral afferent	Nucl. tractus solitarii (pars inferior)	Receive sensory information from • Chemoreceptors in the Glomus caroticum (**B**) • Pressure receptors in the Sinus caroticus	
	Special visceral afferent	Nucl. tractus solitarii (pars superior)	Receives sensory information from the posterior third of the tongue (via the ganglion inferius) (**C**)	
	Somatic afferent	Nucl. spinalis nervi trigemini	Peripheral processes of the intracranial ganglion superius or the extracranial ganglion inferius arise from • Tongue, soft palate, pharyngeal mucosa, and tonsils (**D,E**) • Mucosa of the internal surface of membrana tympanica, Tuba auditiva (plexus tympanicus) (**F**) • Skin of the external ear and meatus acusticus externus (blends with the n. vagus)	

Fig. 31.19 **N. glossopharyngeus in cavitas tympani**
Left anterolateral view. The n. tympanicus contains visceral efferent (presynaptic parasympathetic) fibers for ganglion oticum, as well as somatic afferent fibers for cavitas tympani and tuba auditiva. It joins with sympathetic fibers from plexus caroticus internus (via nn. caroticotympanici) to form the plexus tympanicus.

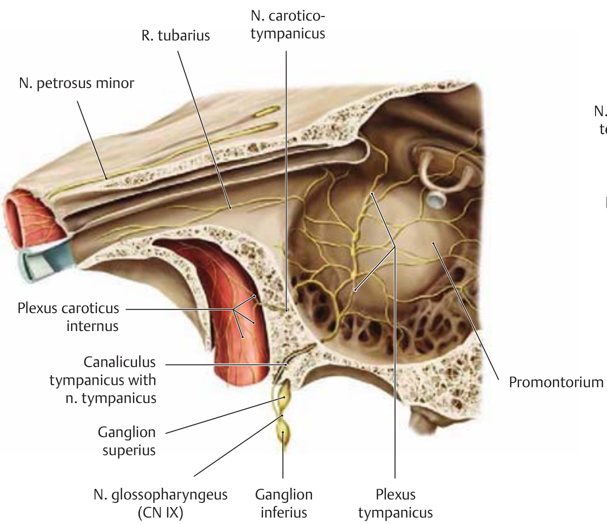
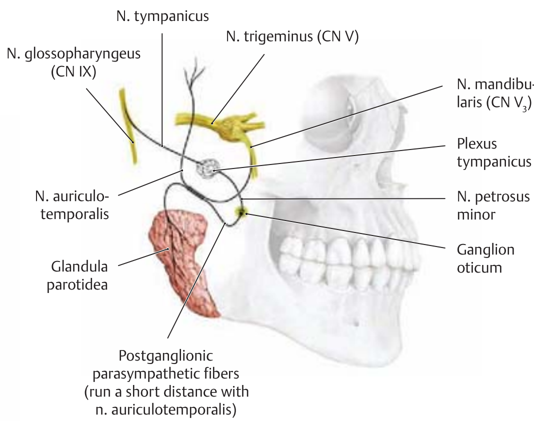
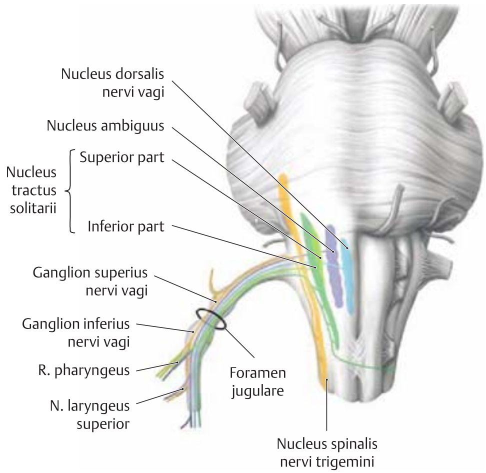


Fig. 31.20 **Visceral efferent (parasympathetic) fibers of CN IX**

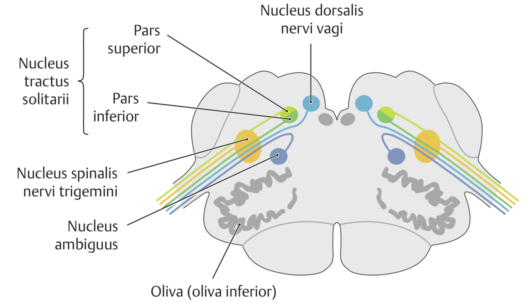


CN X: N. Vagus

Fig. 31.21 Nuclei of n. vagus



A Anterior view of medulla oblongata.



B Cross section through medulla oblongata, superior view.

Table 31.9 N. vagus (CN X)

Course	Fibers	Nuclei	Function	Effects of nerve injury
Emerges from the medulla oblongata; leaves the cavitas cranii through the foramen jugulare. CN X has the most extensive distribution of all the cranial nerves (vagus = “vagabond”), consisting of pars cranialis, cervicalis, thoracica (see p. 91), and abdominalis (see p. 237) parts.	Special visceral efferent (branchio-genic)	Nucl. ambiguus	Innervate: • Pharyngeal muscles (via plexus pharyngeus with CN IX) • Muscles of the soft palate • Laryngeal muscles (n. laryngeus superior supplies the m. cricothyroideus; n. laryngeus inferior supplies all other laryngeal muscles)	The n. laryngeus recurrens supplies visceromotor innervation to the only muscle abducting the vocal cords, the posterior cricoarytenoid. Unilateral destruction of this nerve leads to hoarseness; bilateral destruction leads to respiratory distress (dyspnea).
	Visceral efferent (parasympa-thetic)	Nucl. dorsalis nervi vagi	Synapse in Ganglia praevertebrales or intramurales. Innervate smooth muscle and glands of • Thoracic viscera (**A**) • Abdominal viscera (**A**)	
	Somatic afferent	Nucl. spinalis nervi trigemini	Ganglion superius (jugulare) receives peripheral fibers from • Dura in fossa cranii posterior (**C**) • Skin of ear (**D**), meatus acusticus externus (**E**)	
	Special visceral afferent	Nucl. tractus solitarii (pars superior)	Ganglion inferius receives peripheral processes from • Taste buds on the epiglottis (**F**)	
	Visceral afferent	Nucl. tractus solitatii (pars inferior)	Ganglion inferius receives peripheral processes from • Mucosa of lower pharynx at its esophageal junction (**G**) • Laryngeal mucosa above (n. laryngeus superior) and below (n. laryngeus inferior) the plica vocalis (**G**) • Pressure receptors in the arcus aortae (**B**) • Chemoreceptors in the corpora paraaortica (**B**) • Thoracic and abdominal viscera (**A**)	

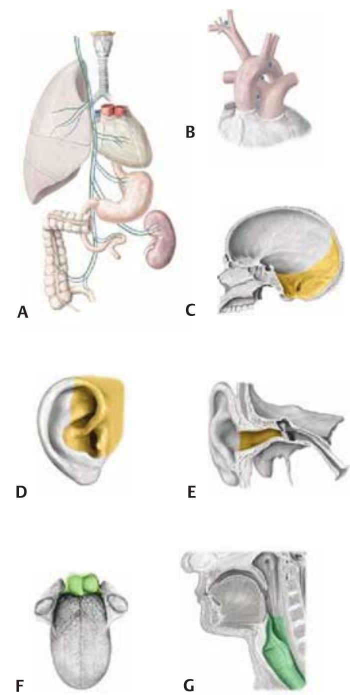
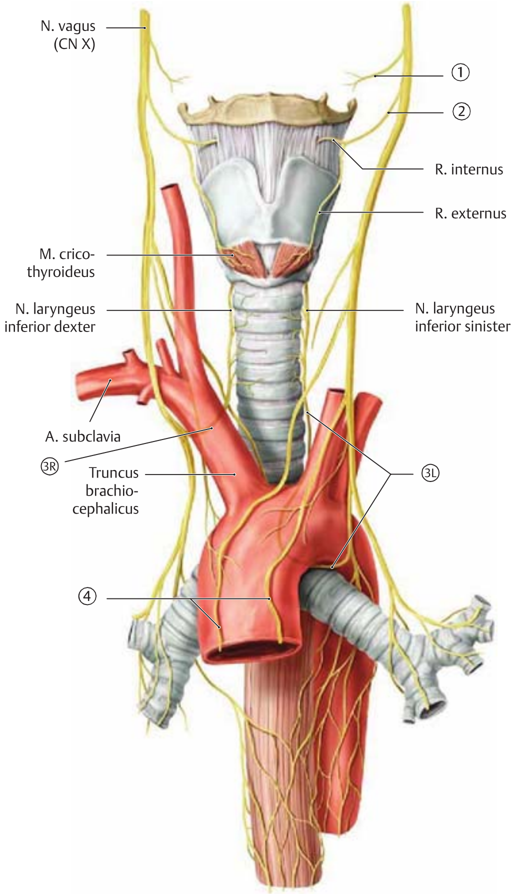


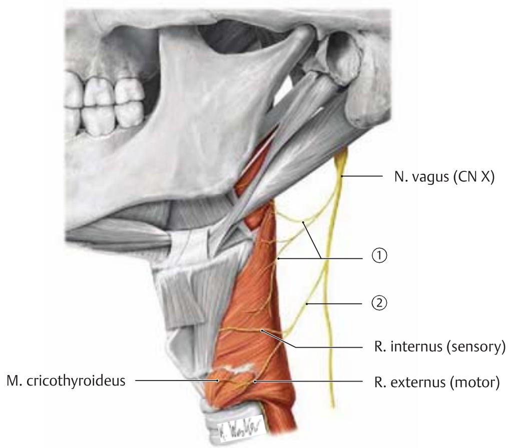
Fig. 31.22 Course of n. vagus

N. vagus gives off four major branches in the neck. The n. laryngeus inferior is the terminal branch of n. laryngeus recurrens. *Note:* The left n. laryngeus recurrens winds around arcus aorta, while the right nerve winds around a. subclavia.

Table 31.10	**Vagus nerve branches in the neck**
①	Rr. pharyngeales
②	N. laryngeus superior
③R	N. laryngeus recurrens dexter
③L	N. laryngeus recurrens sinister
④	Rr. cardiaci cervicales



A Branches of n. vagus in the neck. Anterior view.



B Innervation of the pharyngeal and laryngeal muscles. Left lateral view.

CN XI & XII: N. Accessorius & N. Hypoglossus

The traditional "cranial root" (radix cranialis) of n. accessorius (CN XI) is now considered a part of n. vagus (CN X) that travels with the spinal root (radix spinalis) for a short distance before splitting. The cranial fibers (r. internus) are distributed via n. vagus while the spinal root fibers continue on as the r. externus of n. accessorius (CN XI).

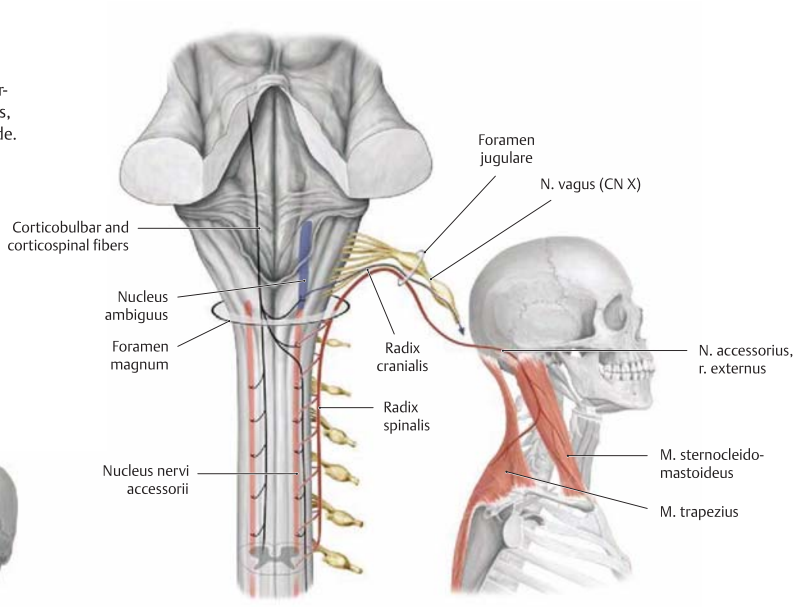


Fig. 31.23 **N. accessorius**
Posterior view of the brainstem with the cerebellum removed. *Note:* For didactic reasons, the muscles are displayed from the right side.

Fig. 31.24 **Lesions of n. accessorius**
Lesion of the right n. accessorius.

A Paralysis of m. trapezius, posterior view.

B Paralysis of m. sternocleidomastoideus, right anterolateral view.

Table 31.11 **N. accessorius (CN XI)**

Course	Fibers	Nuclei	Function	Effects of nerve injury
The radix spinalis emerges from the spinal cord (at the level of C1–C5/6), passes superiorly, and enters the skull through the foramen magnum, where it joins with the radix cranialis from the medulla oblongata. Both roots leave the skull through the foramen jugulare. Within the foramen jugulare, fibers from the radix cranialis pass to the n. vagus (r. internus). The radix spinalis descends to the regio nuchalis as the r. externus.	Special visceral efferent	Nucl. ambiguus (caudal part)	Join CN X and are distributed with the n. laryngeus recurrens. Innervate: • All laryngeal muscles (except m. cricothyroideus)	*Trapezius paralysis:* drooping of shoulder on affected side and difficulty raising arm above horizontal plane. This paralysis is a concern during neck operations (e.g., lymph node biopsies). An injury of the accessory nerve will not result in complete trapezius paralysis (the muscle is also innervated by segments C3 and C4/5). *Sternocleidomastoid paralysis:* torticollis (wry neck, i.e., difficulty turning head). Unilateral lesions cause flaccid paralysis (the muscle is supplied exclusively by the accessory nerve). Bilateral lesions make it difficult to hold the head upright.
	Somatic efferent	Nucl. nervi accessorii	Form the r. externus of the n. accessorius. Innervate: • M. trapezius • M. sternocleidomastoideus	

Fig. 31.25 **N. hypoglossus**
Posterior view of the brainstem with the cerebellum removed.
Note: C1, which innervates m. thyrohyoideus and m. geniohyoideus, runs briefly with n. hypoglossus.

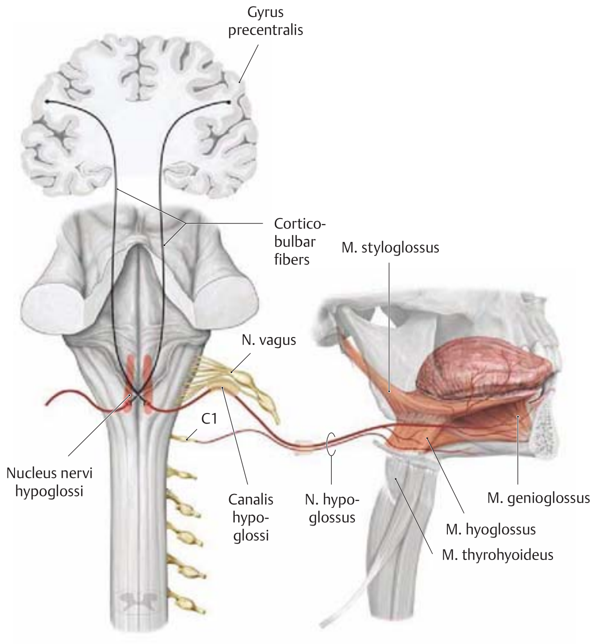
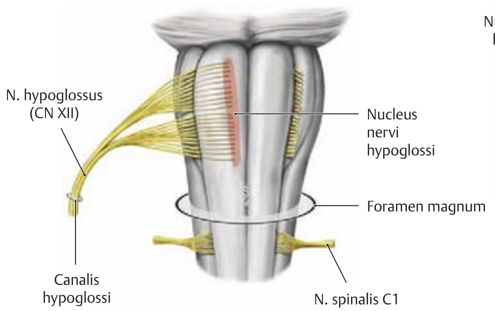
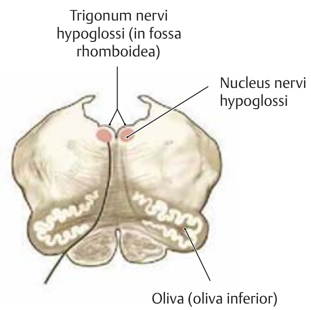


Fig. 31.26 **Nuclei of n. hypoglossus**
Note: The nucleus nervi hypoglossi is innervated by cortical neurons from the contralateral side.



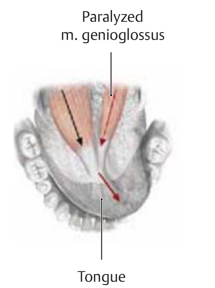
A Anterior view.



B Cross section through medulla oblongata.

Fig. 31.27 **Lesions of n. hypoglossus**
Superior view.

A Normal mm. genioglossi.



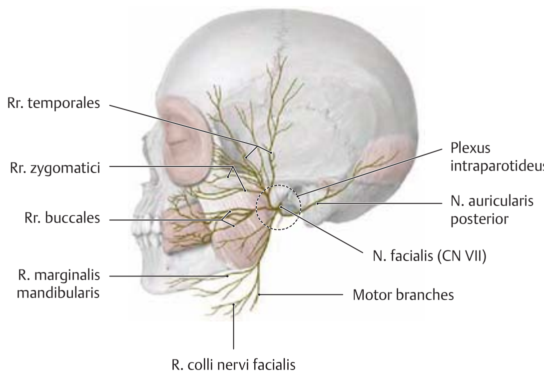
B Unilateral nuclear or peripheral lesion.

Table 31.12 **N. hypoglossus (CN XII)**

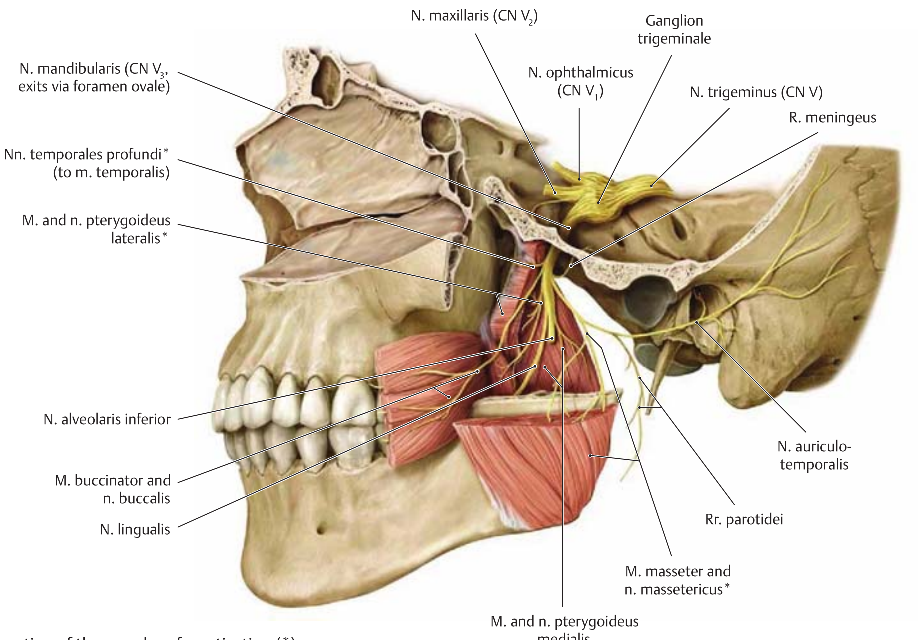
Course	Fibers	Nuclei	Function	Effects of nerve injury
Emerges from the medulla oblongata, leaves the cavitas cranii through the canalis nervi hypoglossi, and descends laterally to the n. vagus. CN XII enters the radix linguae above the os hyoideum.	Somatic efferent	Nucl. nervi hypoglossi	Innervates: • Intrinsic and extrinsic muscles of the tongue (except the m. palatoglossus, supplied by CN X)	Central hypoglossal paralysis (supranuclear): tongue deviates *away* from the side of the lesion Nuclear or peripheral paralysis: tongue deviates *toward* the affected side (due to preponderance of muscle on healthy side) Flaccid paralysis: both nuclei injured; tongue cannot be protruded

Innervation of the Face

Fig. 32.1 Motor innervation of the face
Left lateral view. Five branches of n. facialis (CN VII) provide motor innervation to the muscles of facial expression. N. mandibularis of the trigeminal nerve (CN V_3) supplies motor innervation to the muscles of mastication.

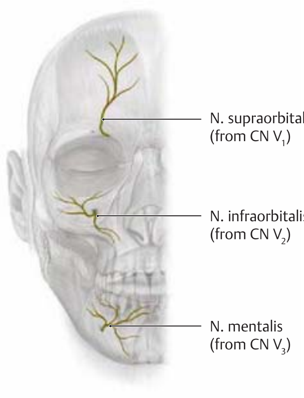


A Motor innervation of the muscles of facial expression.

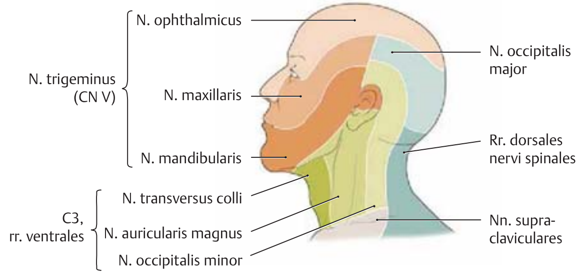


B Motor innervation of the muscles of mastication (*).

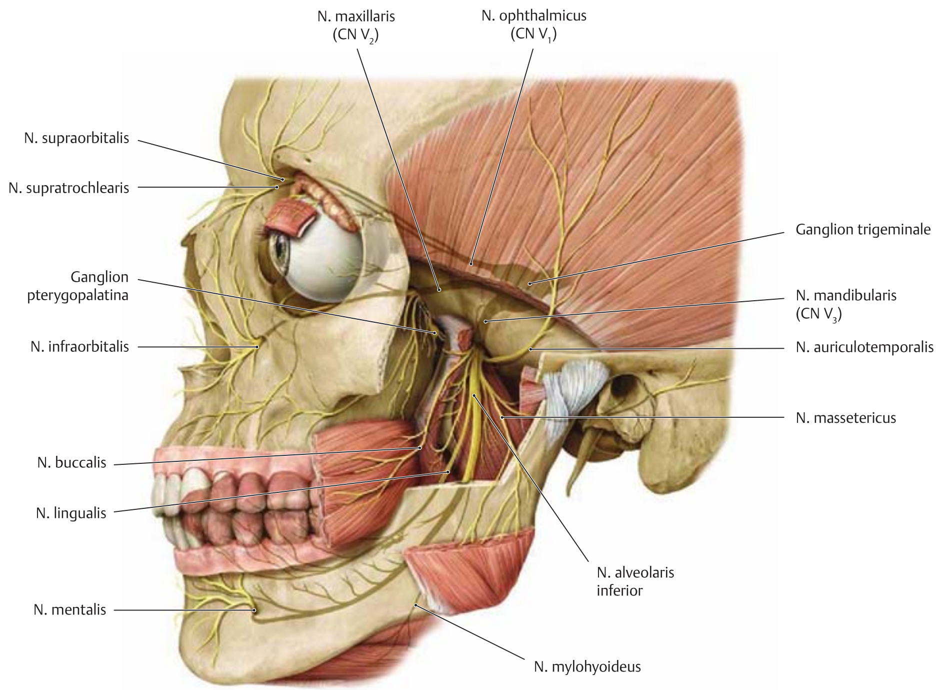
Fig. 32.2 Sensory innervation of the face



A Sensory branches of n. trigeminus, anterior view. The sensory branches of the three divisions emerge from foramina supraorbitalis, infraorbitalis, and mentalis, respectively.



B Sensory innervation of the head and neck, left lateral view. The occiput and nuchal regions are supplied by the rami dorsales (blue) of the spinal nerves (n. occipitalis major is the ramus dorsalis of C2).

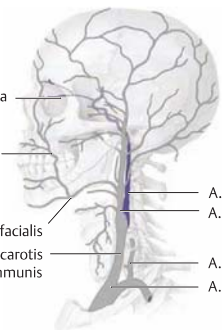


C Divisions of n. trigeminus, left lateral view.

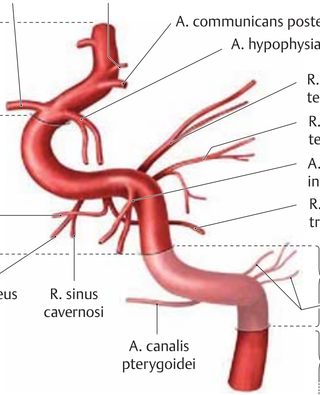
Arteries of the Head & Neck

The head and neck are supplied by branches of a. carotis communis. A. carotis communis splits at the bifurcatio carotidis into two branches: a. carotis interna and a. carotis externa. A. carotis interna chiefly supplies the brain (p. 606), although its branches anastomose with a. carotis externa in the orbita and septum nasi. A. carotis externa is the major supplier of structures of the head and neck.

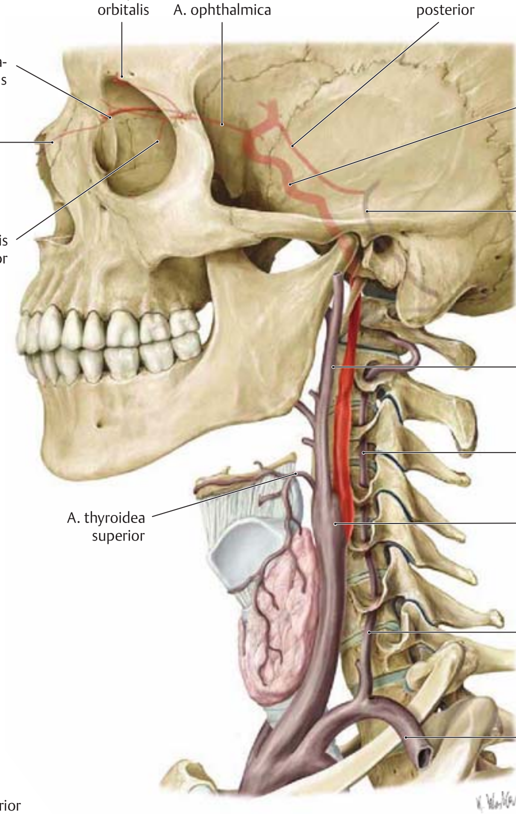
Fig. 32.3 A. carotis interna
Left lateral view. The most important extracerebral branch of a. carotis interna isthe a. ophthalmica, which supplies the upper septum nasi (p. 524) and the orbita (p. 512). See pp. 608–609 for arteries of the brain.



A Schematic.



B Parts and branches of a. carotis interna.

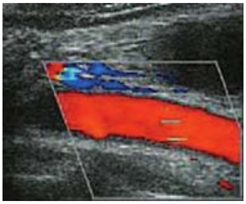


C Course of a. carotis interna.

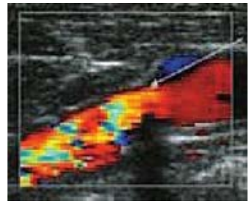
Clinical

Carotid artery atherosclerosis

The carotid artery is often affected by atherosclerosis, a hardening of arterial walls due to plaque formation. The examiner can determine the status of the arteries using ultrasound. *Note:* The absence of atherosclerosis in the carotid artery does not preclude coronary heart disease or atherosclerotic changes in other locations.



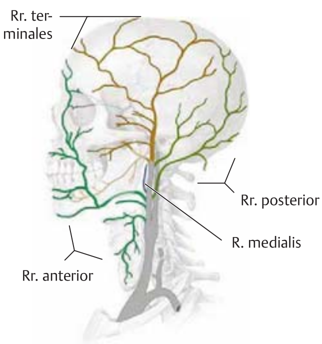
A A. carotis communis with "normal" flow.



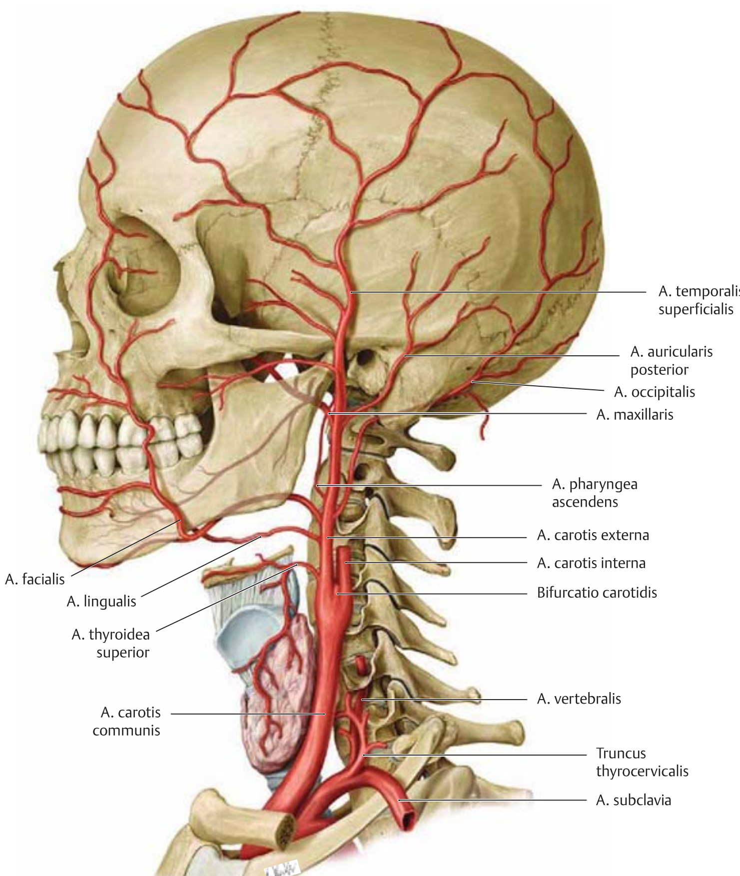
B Calcified plaque in the carotid bulb.

Fig. 32.4 **A. carotis externa: Overview**

Left lateral view.



A Schematic of a. carotis externa.

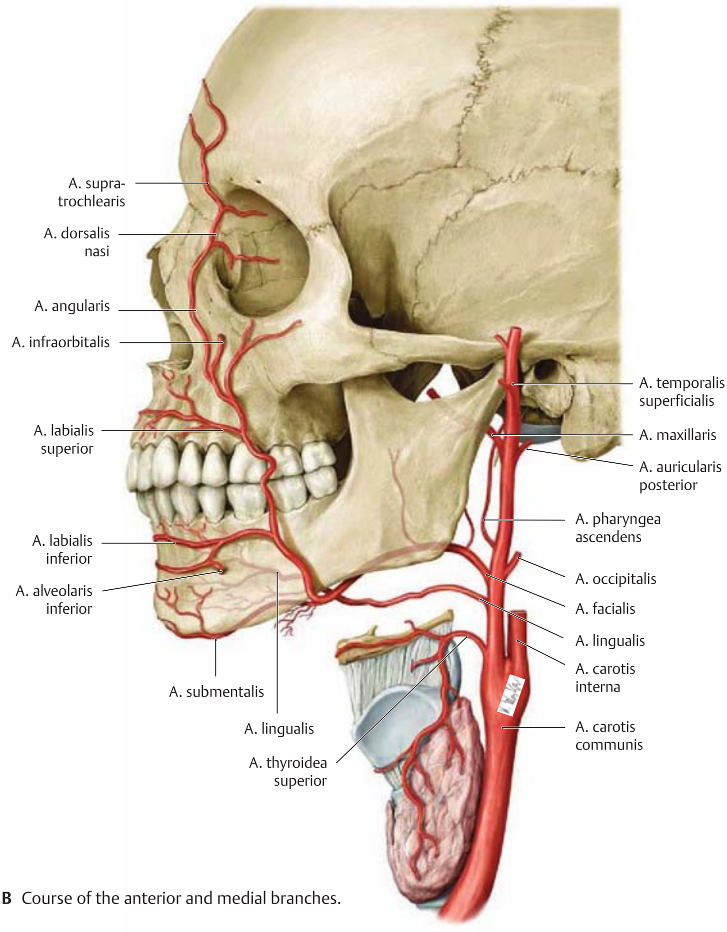


B Course of a. carotis externa.

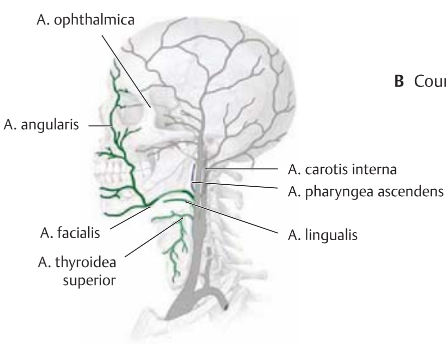
Table 32.1	**Rr. of the A. carotis externa**
Group	**Artery**
Anterior (p. 492)	A. thyroidea superior
	A. lingualis
	A. facialis
Medial (p. 492)	A. pharyngea ascendens
Posterior (p. 493)	A. occipitalis
	A. auricularis posterior
Terminal (p. 494)	A. maxillaris
	A. temporalis superficialis

A. Carotis Externa: Anterior, Medial & Posterior Branches

Fig. 32.5 **Anterior and medial branches**
Left lateral view. The arteries of the anterior aspect supply the anterior structures of the head and neck, including the orbita (p. 510), ear (p. 534), larynx (p. 575), pharynx (p. 556), and oral cavity. *Note:* The a. angularis anastomoses with the a. dorsalis nasi of a. carotis interna (via a. ophthalmica).



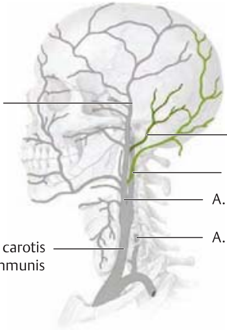
B Course of the anterior and medial branches.



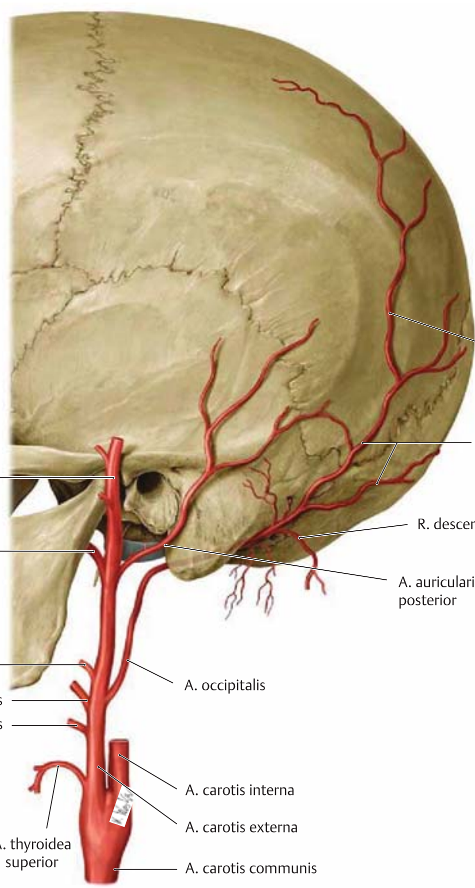
A Arteries of the anterior and medial branches. The copious blood supply to the face makes facial injuries bleed profusely, but heal quickly. There are extensive anastomoses between branches of a. carotis externa, and between a. carotis externa and branches of a. ophthalmica.

Fig. 32.6 **Posterior branches**

Left lateral view. The posterior branches of a. carotis externa supply the ear (p. 534), posterior skull (p. 499), and posterior neck muscles (p. 585).



A Arteries of the posterior branch.



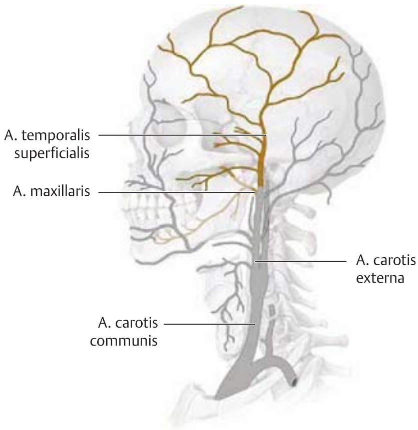
B Course of the posterior branches.

Table 32.2	**Rr. anterior, medial, and posterior of the a. carotis externa**	
Branch	**Artery**	**Divisions and distribution**
R. anterior	A. thyroidea superior	R. glandularis anterior (to glandula thyroidea); a. laryngea superior; r. sternocleidomastoideus
	A. lingualis	Rr. dorsales linguae (to base of tongue, epiglottis); a. sublingualis (to glandula sublingualis, tongue, oral floor, oral cavity)
	A. facialis	A. palatina ascendens (to pharyngeal wall, soft palate, Tuba auditiva); rr. tonsillares (to tonsilla palatina); a. submentalis (to oral floor, glandula submandibularis); aa. labiales; a. angularis (radix nasi)
R. medius	A. pharyngea ascendens	Rr. pharyngei; a. tympanica inferior (to mucosa of inner ear); a. meningea posterior
R. posterior	A. occipitalis	Rr. occipitales; r. descendens (to posterior neck muscles)
	A. auricularis posterior	A. stylomastoidea (to n. facialis in canalis nervi facialis); a. tympanica posterior; r. auricularis; r. occipitalis; r. parotideus
For terminal branches, see Table 32.3.		

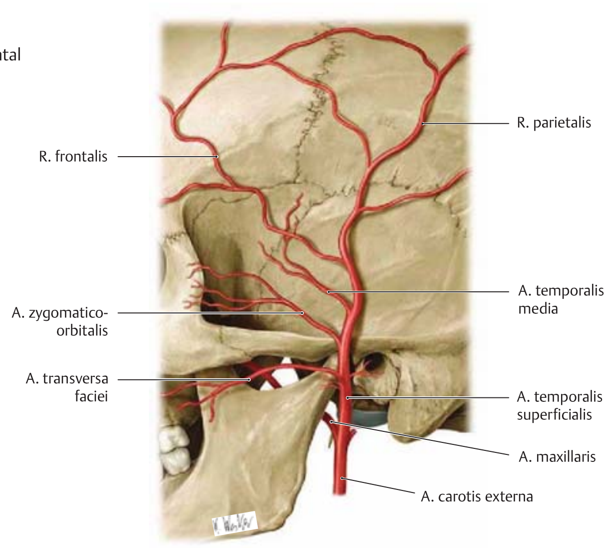
A. Carotis Externa: Terminal Branches

The terminal branches of the external carotid artery consist of two major arteries: a. temporalis superficialis and a. maxillaris. A. temporalis superficialis supplies the lateral skull. A. maxillaris is a major artery for internal structures of the face.

Fig. 32.7 **A. temporalis superficialis**
Left lateral view. Inflammation of a. temporalis superficialis due to temporal arteritis can cause severe headaches. The course of the frontal branch of the artery can often be seen superficially under the skin of elderly patients.



A Arteries of the terminal branch.



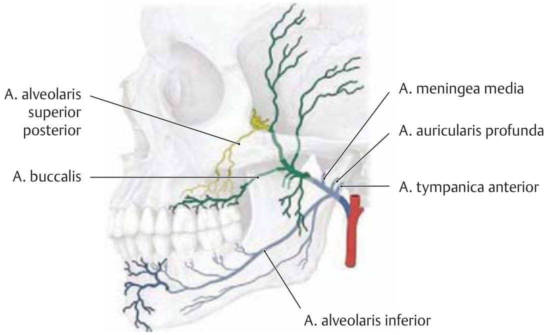
B Course of a. temporalis superficialis.

Table 32.3 **Rr. terminales of the a. carotis externa**

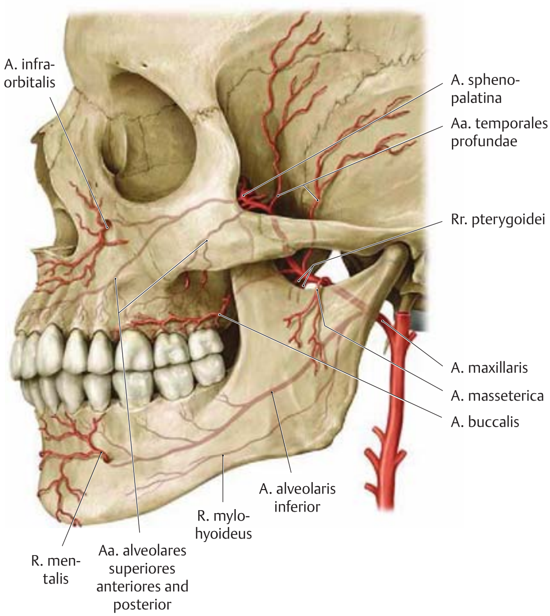
<table>
<tr><th>Branch</th><th colspan="2">Artery</th><th colspan="2">Divisions and distribution</th></tr>
<tr><td rowspan="8">Rr. terminales</td><td colspan="2">A. temporalis superficialis</td><td colspan="2">A. transversa faciei (to soft tissues below the arcus zygomaticus); rr. frontales; rr. parietales; a. zygomaticoorbitalis (to paries orbitalis lateralis)</td></tr>
<tr><td rowspan="7">A. maxillaris</td><td>Pars mandibularis</td><td colspan="2">A. alveolaris inferior (to mandibula, teeth, gingiva); a. meningea media; a. auricularis profunda (to articulatio temporomandibulare, meatus acusticus externus); a. tympanica anterior</td></tr>
<tr><td>Pars pterygoidea</td><td colspan="2">A. masseterica; aa. temporales profundae; rr. pterygoidei; a. buccalis</td></tr>
<tr><td rowspan="5">Pars pterygopalatina</td><td colspan="2">A. alveolaris superior posterior (to maxillary molars, sinus maxillaris, gingiva); a. infraorbitalis (to alveoli dentales)</td></tr>
<tr><td rowspan="2">A. palatina descendens</td><td>A. palatina major (to hard palate)</td></tr>
<tr><td>A. palatina minor (to soft palate, tonsilla palatina, pharyngeal wall)</td></tr>
<tr><td rowspan="2">A. sphenopalatina</td><td>Aa. nasales posteriores laterales (to lateral wall of nasal cavity, conchae)</td></tr>
<tr><td>Rr. septales posteriores (to septum nasi)</td></tr>
</table>

***Fig. 32.8* A. maxillaris**

Left lateral view. A. maxillaris consists of three parts: mandibular (blue), pterygoid (green), and pterygopalatine (yellow).



A Divisions of a. maxillaris.

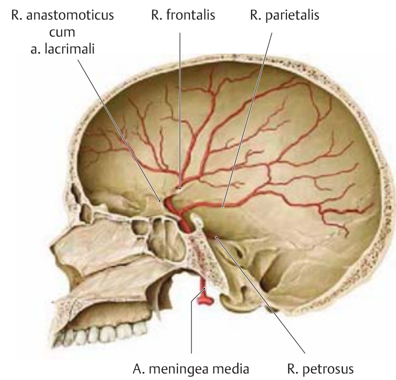


B Course of a. maxillaris.

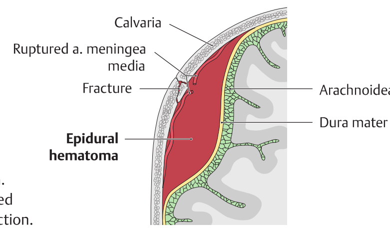
Clinical

A. meningea media

The a. meningea media supplies the meninges and overlying calvaria. Rupture of the artery (generally due to head trauma) results in an epidural hematoma.



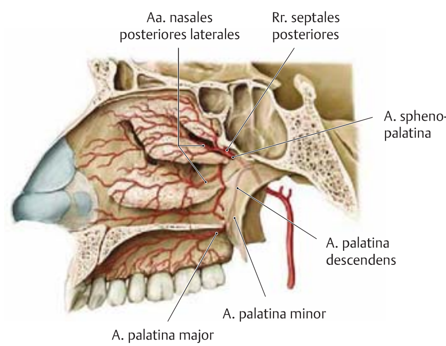
A Right a. meningea media, medial view of opened skull.



B Epidural hematoma. Schematized coronal section.

A. sphenopalatina

The a. sphenopalatina supplies the wall of the nasal cavity. Excessive nasopharyngeal bleeding from the branches of a. sphenopalatina may necessitate ligation of a. maxillaris in fossa pterygopalatina.

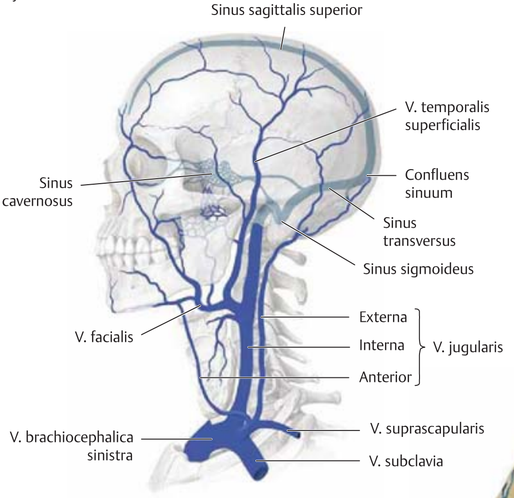


C Lateral wall of nasal cavity, left lateral view.

Veins of the Head & Neck

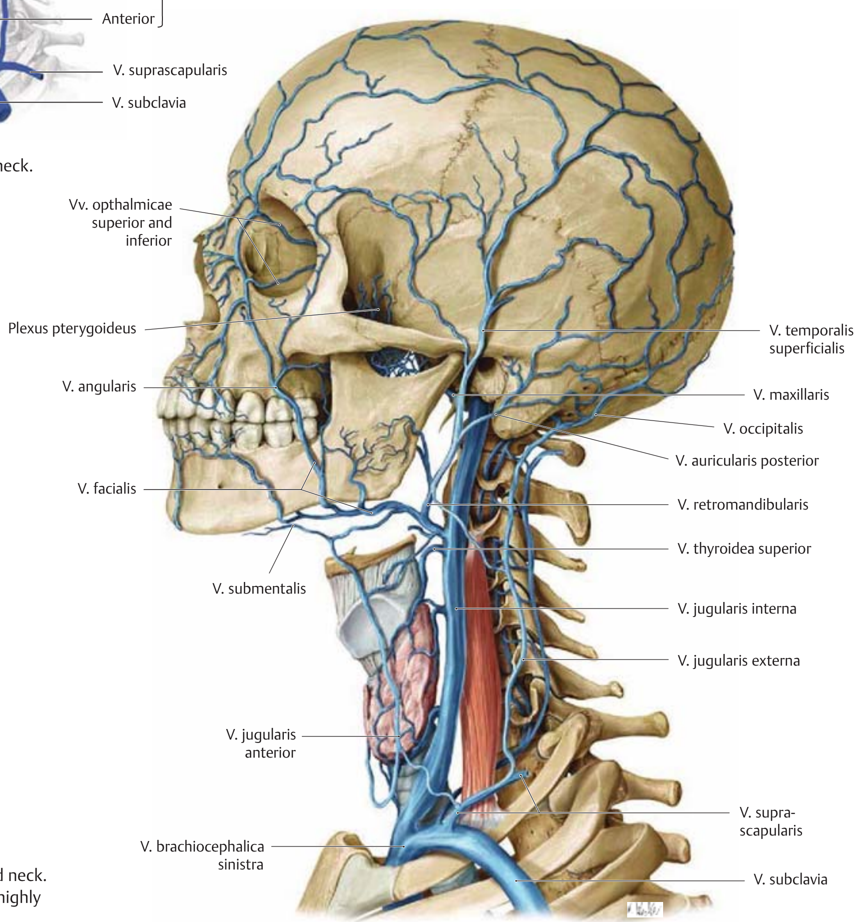
Fig. 32.9 Veins of the head and neck

Left lateral view. The veins of the head and neck drain into v. brachiocephalica. *Note:* The left and right vv. brachiocephalicae are not symmetrical.



A Principal veins of the head and neck.

Table 32.4 Principal superficial veins		
Vein	**Region drained**	**Location**
V. jugularis interna	Interior of skull (including brain)	Within vagina carotica
V. jugularis externa	Superficial head	Within fascia cervicalis superficialis
V. jugularis anterior	Neck, portions of head	



B Superficial veins of the head and neck. *Note:* The course of the veins is highly variable.

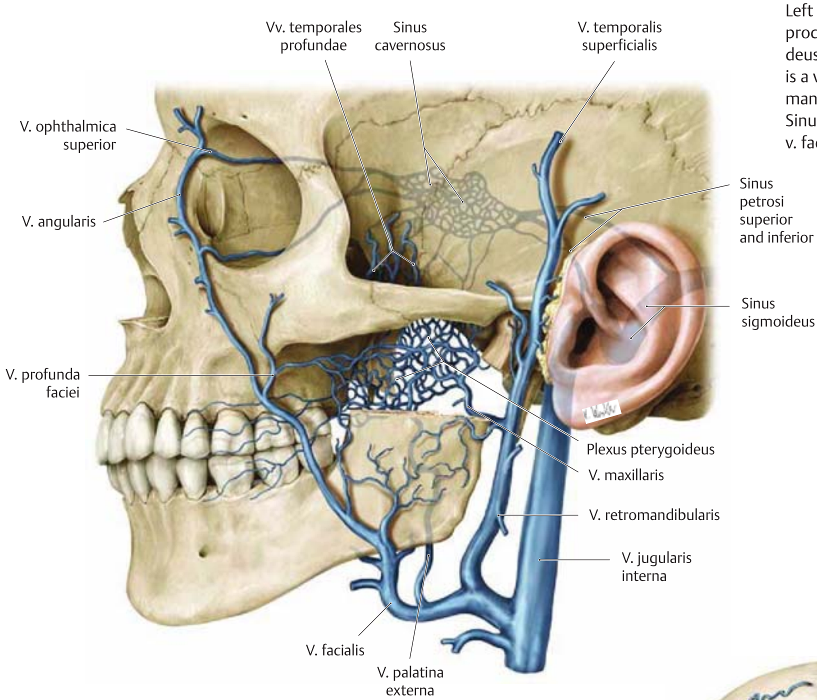


Fig. 32.10 **Deep veins of the head**
Left lateral view. *Removed:* Upper ramus, processus condylaris and processus coronoideus of mandibula. The plexus pterygoideus is a venous network situated between ramus mandibulae and the muscles of mastication. Sinus cavernosus connects branches of v. facialis to sinus sigmoideus.

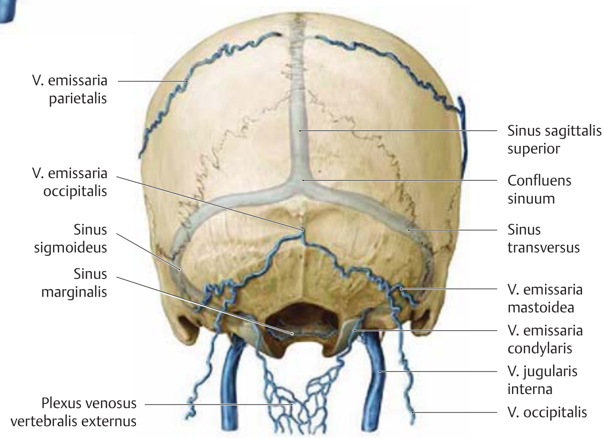


Fig. 32.11 **Veins of the occiput**
Posterior view. The superficial veins of the occiput communicate with sinus durae matris via vv. emissariae that drain to vv. diploicae (calvaria, p. 457). *Note:* The plexus venosus vertebralis externus traverses the entire length of the spine (p. 611).

Table 32.5 **Venous anastomoses**

The extensive venous anastomoses in this region provide routes for the spread of infections.

Extracranial vein	Connecting vein	Venous sinus
V. angularis	V. ophthalmica superior and inferior	Sinus cavernosus*
Vv. of palatine tonsil	Plexus pterygoideus; v. ophthalmica inferior	
V. temporalis superficialis	Vv. emissariae parietales	Sinus sagittalis superior
V. occipitalis	V. emissaria occipitalis	Sinus transversus, confluens sinuum
V. auricularis posterior	V. emissaria mastoidea	Sinus sigmoideus
Plexus venosus vertebralis externus	V. emissaria condylaris	

*Deep spread of bacterial infection from the facial region may result in sinus cavernosus thrombosis.

Topography of the Superficial Face

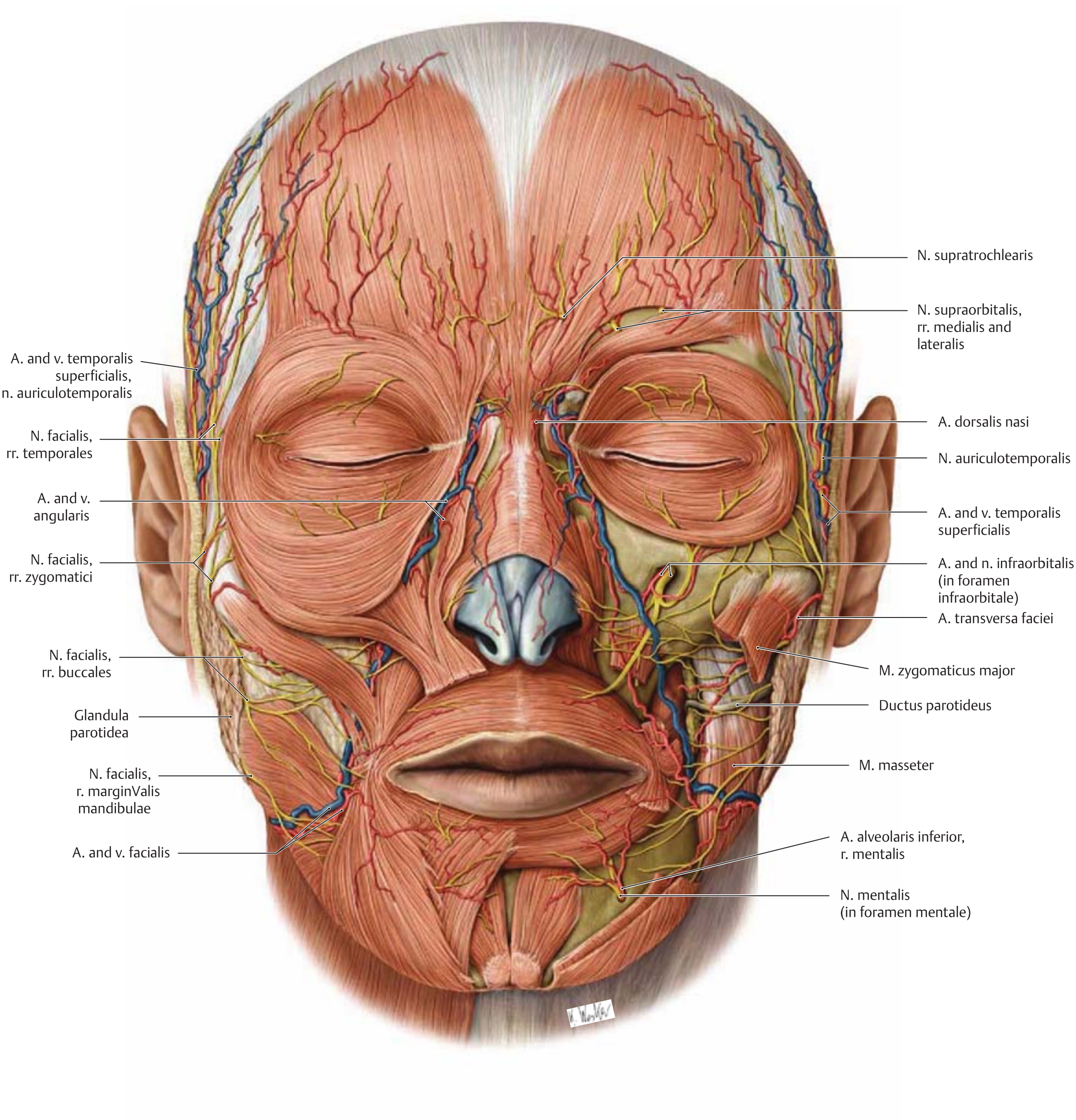
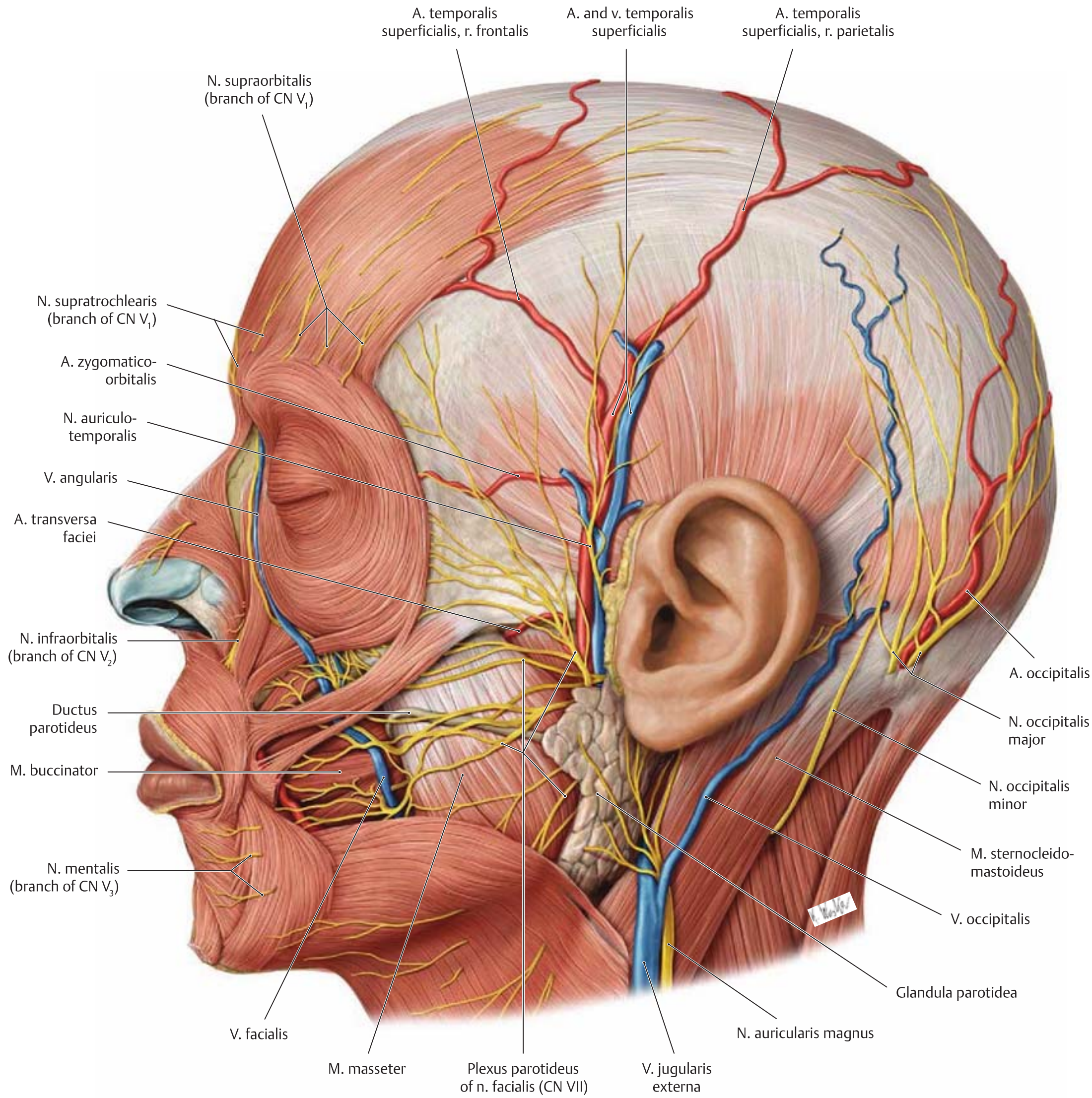


Fig. 32.12 **Superficial neurovasculature of the face**
Anterior view. *Removed:* Skin and fatty subcutaneous tissue; muscles of facial expression (left side).

Fig. 32.13 **Superficial neurovasculature of the head**
Left lateral view.



Topography of the Parotid Region & Fossa Temporalis

Fig. 32.14 **Parotid region**
Left lateral view. *Removed:* Glandula parotidea, m. sternocleidomastoideus, and veins of the head. *Revealed:* Parotid bed and trigonum caroticum.

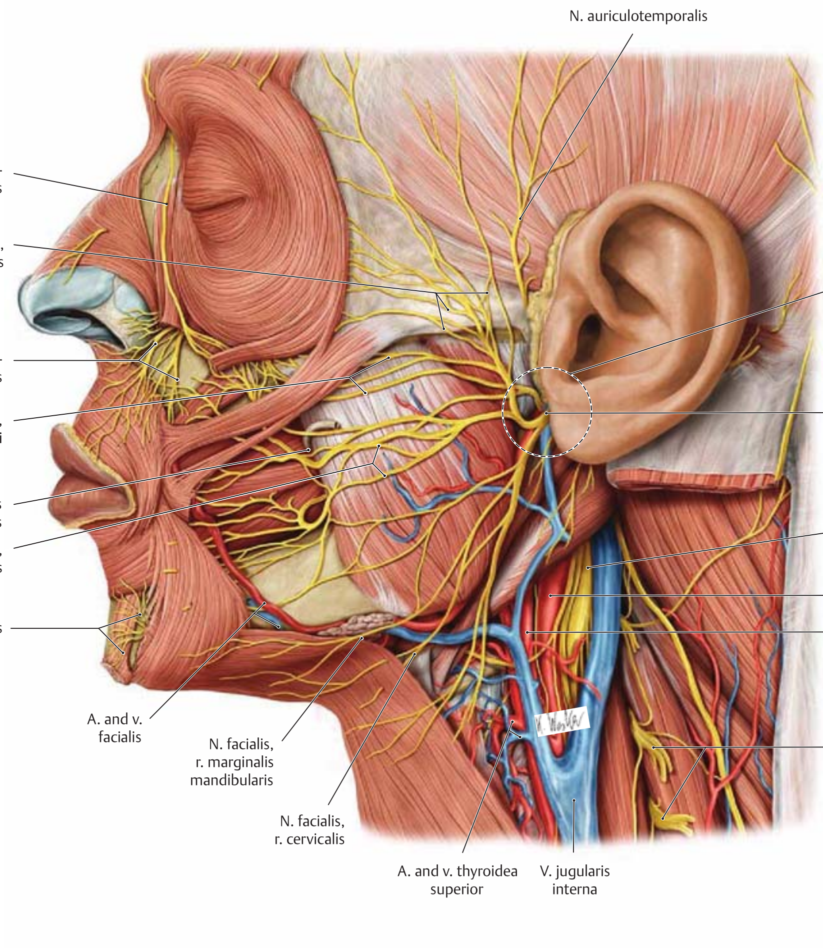
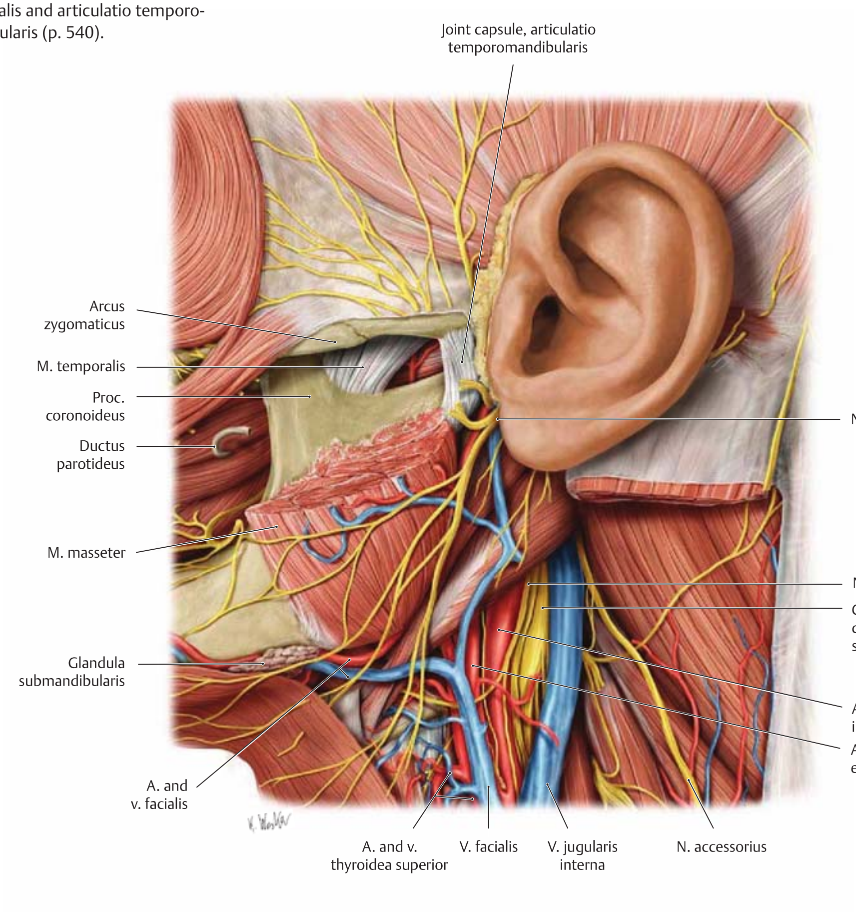


Fig. 32.15 **Fossa temporalis**
Left lateral view. *Removed:* M. sternocleidomastoid and m. masseter. *Revealed:* Fossa temporalis and articulatio temporomandibularis (p. 540).



Topography of Fossa Infratemporalis

Fig. 32.16 **Fossa infratemporalis: Superficial layer**
Left lateral view. *Removed:* Ramus mandibulae. *Note:* The n. mylohyoideus (see p. 547) branches from n. alveolaris inferior just before foramen mandibulae.

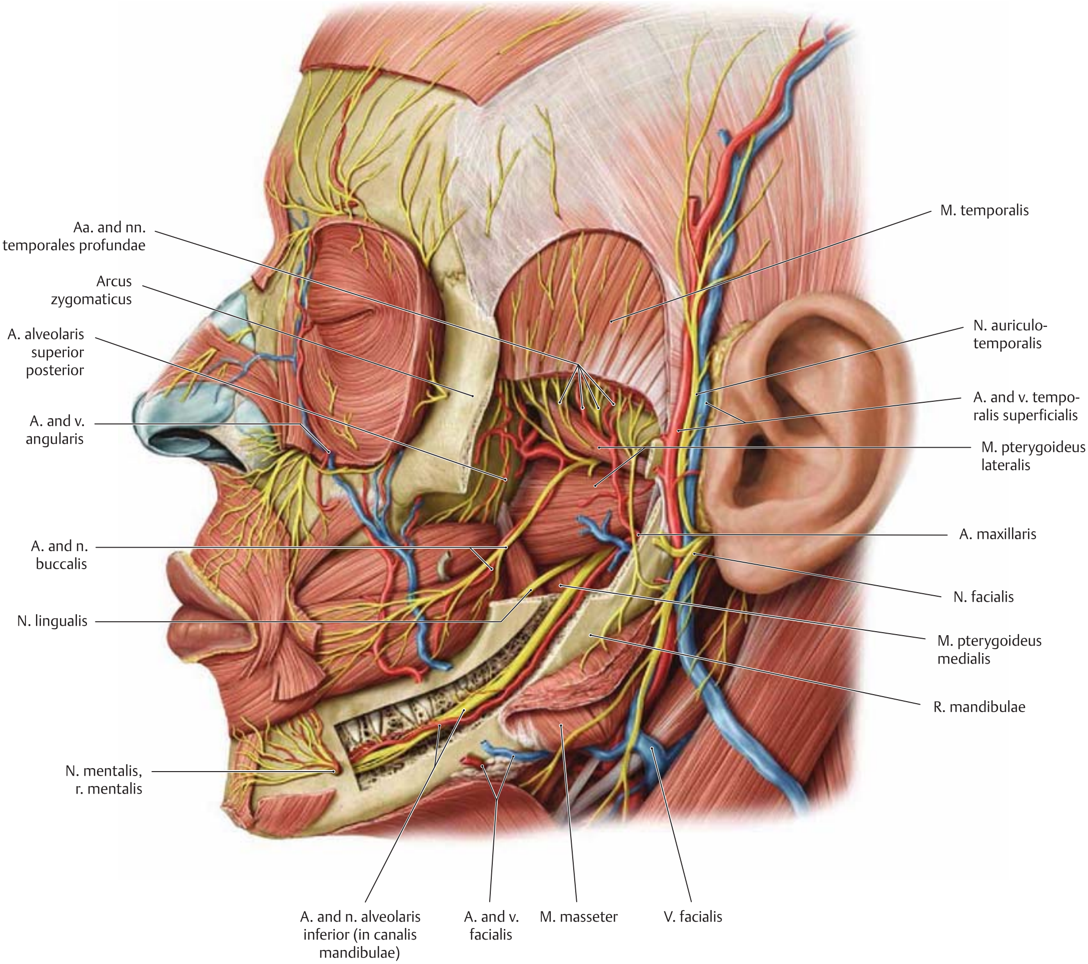


Fig. 32.17 **Deep layer**

Left lateral view. *Removed:* M. pterygoideus lateralis (both heads). *Revealed:* Deep fossa infratemporalis and n. mandibularis as it enters canalis mandibulae via foramen ovale in the roof of the fossa.

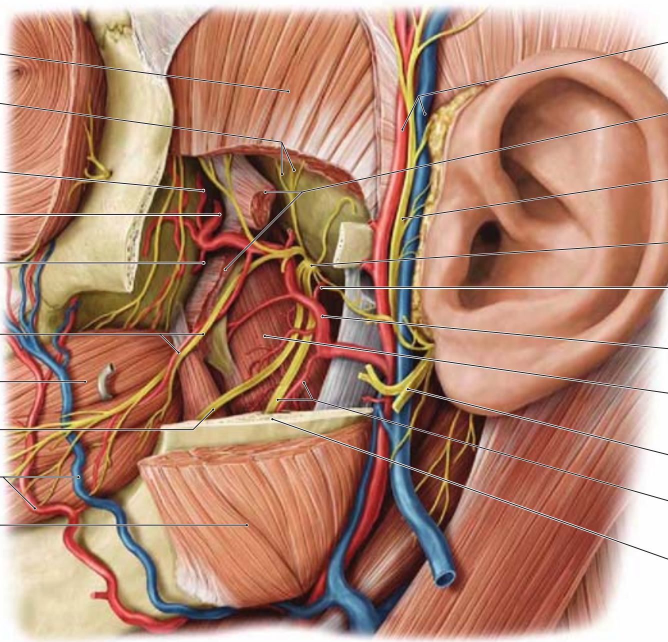
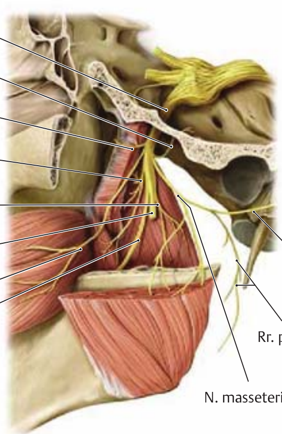
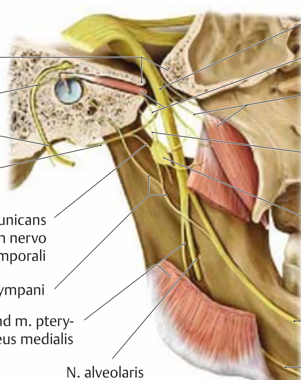


Fig. 32.18 **N. mandibularis (CN V_3) in fossa infratemporalis**



A Left lateral view.



B Medial view.

Topography of Fossa Pterygopalatina

The fossa pterygopalatina is a small pyramidal space just inferior to the apex of the orbita. It is continuous with fossa infratemporalis, with no clear line of demarcation between them. Fossa pterygopalatina is a crossroads for neurovascular structures traveling between fossa cranii media, orbita, nasal cavity, and oral cavity.

Table 32.6 Borders of the Fossa pterygopalatina

Direction	Boundaries	Direction	Boundaries
Superior	Os sphenoidale (ala major), junction with Fissura orbtalis inferior	Posterior	Proc. pterygoideus (lamina lateralis)
Anterior	Tuber maxillae	Lateral	Communicates with the fossa infratemporalis via the fissura pterygomaxillaris
Medial	Os palatinum (lamina perpendicularis)	Inferior	None; opens into the spatium retropharyngeum

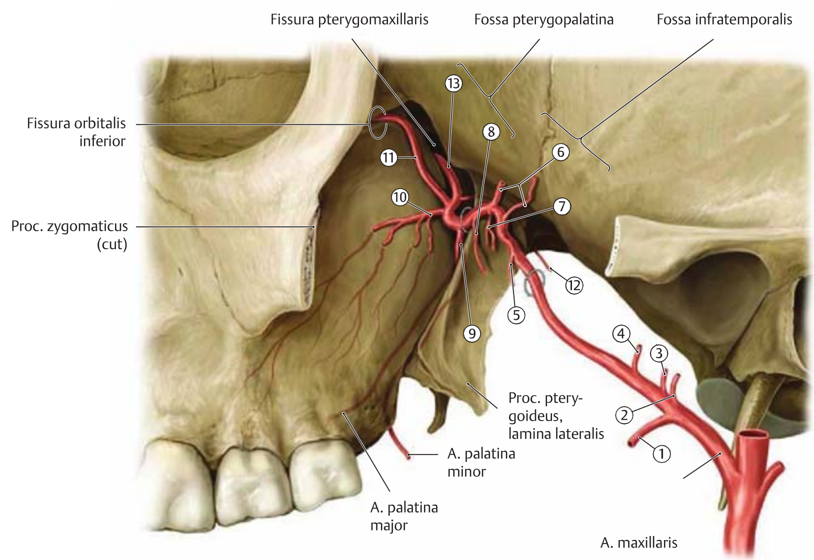


***Fig. 32.19* Arteries in fossa pterygopalatina**
Left lateral view into area. A. maxillaris passes over m. pterygoideus lateralis in fossa infratemporalis (see Fig. 32.16) and enters fossa pterygopalatina through fissura pterygomaxillaris.

Table 32.7 Rr. of the a. maxillaris

Part	Artery		Distribution
Pars mandibularis	① A. alveolaris inferior		Mandibula, teeth, gingiva
	② A. tympanica anterior		Cavitas tympanica
	③ A. auricularis profunda		Articulatio temporomandibulare, meatus acusticus externus
	④ A. meningea media		Calvaria, dura, fossa cranii ant. and med.
Pars pterygoidea	⑤ A. masseterica		M. masseter
	⑥ Aa. temporales profundae		M. temporalis
	⑦ Rr. pterygoidei		M. pterygoideus
	⑧ A. buccalis		Buccal mucosa
Pars pterygopalatina	⑨ A. palatina descendens	A. palatina major	Hard palate
		A. palatina minor	Soft palate, tonsilla palatina, pharyngeal wall
	⑩ A. alveolaris superior posterior		Maxillary molars, sinus maxillaris, Gingiva
	⑪ A. infraorbitalis		Alveoli dentales of maxilla
	⑫ A. canalis pterygoidei		
	⑬ A. sphenopalatina	Aa. nasales posteriores laterales	Paries lateralis of cavitas nasalis, choanae
		Rr. septales posteriores	Septum nasi

N. maxillaris of n. trigeminus (CN V_2, see p. 477) passes from fossa cranii media through the foramen rotundum into fossa pterygopalatina. The parasympathetic ganglion pterygopalatinum receives presynaptic fibers from the n. petrosus major (the parasympathetic root of n. intermedius of n. facialis). The preganglionic fibers of ganglion pterygopalatinum synapse with ganglion cells that innervate the lacrimal, small palatal, and small nasal glands. The sympathetic fibers of n. petrosus profundus (sympathetic root) and sensory fibers of n. maxillaris (sensory root) pass through ganglion pterygopalatinum without synapsing.

Fig. 32.20 **Nerves in the pterygopalatine fossa**
Left lateral view.

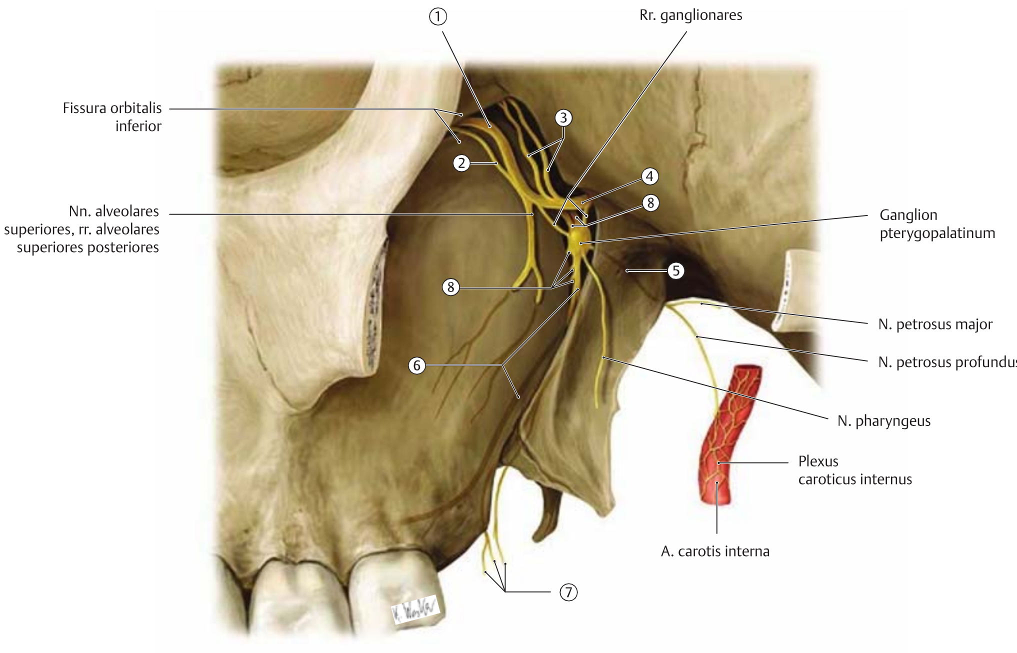
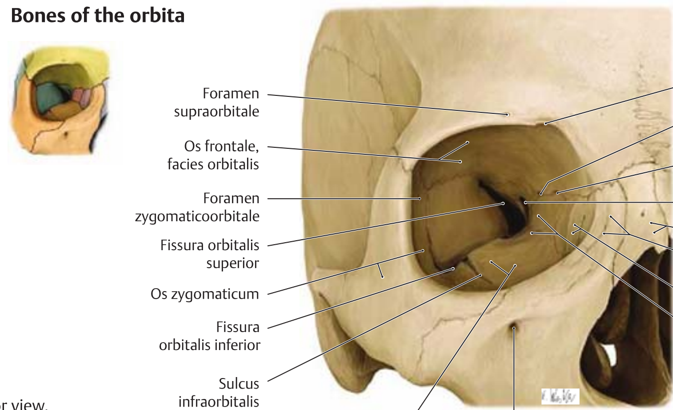


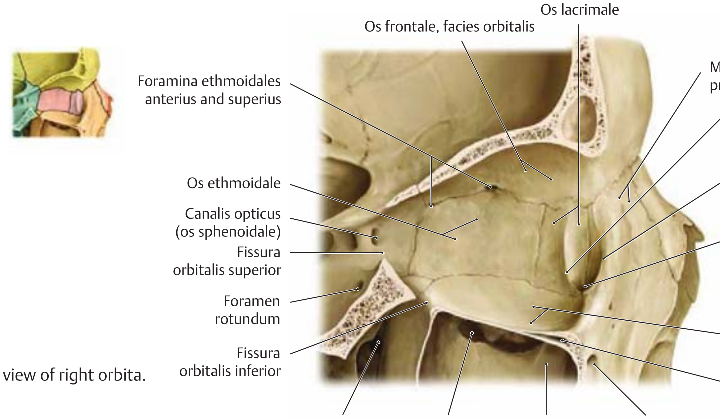
Table 32.8 **Passage of neurovascular structures into fossa pterygopalatina**			
Origin of structures	**Passageway**	**Transmitted nerves**	**Transmitted vessels**
Orbita	Fissura orbitalis inferior	① N. infraorbitalis	A. infraorbitalis (and accompanying vv.)
		② N. zygomaticus	V. ophthalmica inferior
		③ Rr. orbitales (from CN V_2)	
Fossa cranii media	Foramen rotundum	④ N. maxillaris (CN V_2)	
Basis cranii	Canalis pterygoideus	⑤ N. canalis pterygoidei (n. petrosus major and n. petrosus minor)	A. canalis pterygoidei (with accompanying vv.)
Palatum	Foramen palatinum majus	⑥ N. palatinus major	A. palatina descendens
			A. palatina major
	Foramen palatinum minus	⑦ N. palatinus minor	Aa. patatinae minores (r. terminalis of a. palatina descendens)
Cavitas nasalis	Foramen sphenopalatinum	⑧ Medial and lateral rr. nasales posteriores superiores and inferiores (from n. nasopalatinus, CN V_2)	A. sphenopalatina (with accompanying vv.)

Bones of the Orbita

Fig. 33.1 **Bones of the orbita**



A Anterior view.

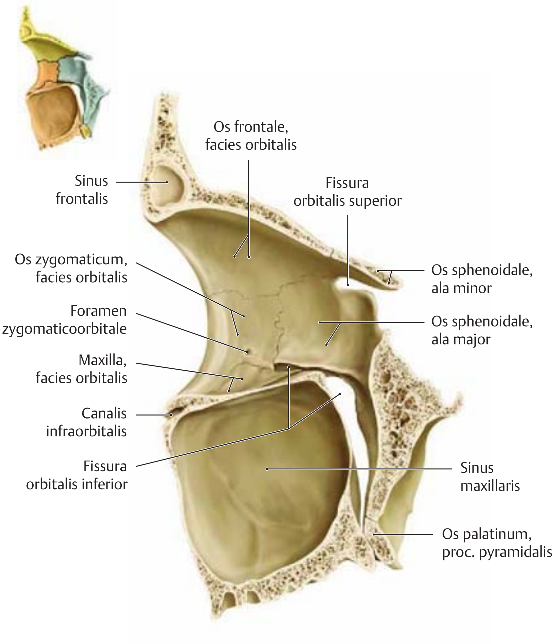


B Lateral view of right orbita.

Table 33.1 **Openings in the orbita for neurovascular structures**

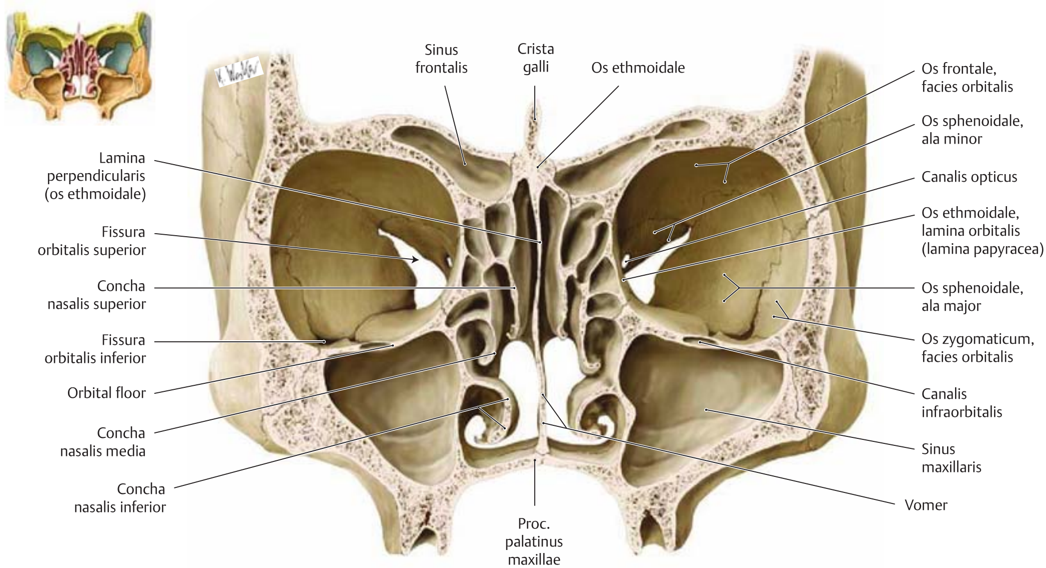
Opening*	Nerves		Vessels
Canalis opticus	N. opticus (CN II)		A. ophthalmica
Fissura orbitalis superior	N. oculomotorius (CN III) N. trochlearis (CN IV) N. abducens (CN VI)	N. trigeminus, ophthalmic division (CN V_1) • N. lacrimalis • N. frontalis • N. nasociliaris	V. ophthalmica superior
Fissura orbitalis inferior	N. infraorbitalis (CN V_2) N. zygomaticus (CN V_2)		A. and v. infraorbitalis, v. ophthalmica inferior
Canalis infraorbitalis	N. infraorbitalis (CN V_2), a., and v.		
Foramen supraorbitale	N. supraorbitalis (r. lateralis)		A. supraorbitalis
Incisura frontalis	N. supraorbitalis (r. medialis)		A. supratrochlearis
Foramen ethmoidale anterior	N., a., and v. ethmoidalis anterior		
Foramen ethmoidale posterior	N., a., and v. ethmoidalis posterior		

* The canalis nasolacrimalis transmits the duchtus nasolacrimalis.



C Medial view of right orbita.

Table 33.2 **Structures surrounding the orbita**	
Direction	**Bordering structure**
Superior	Sinus frontalis
	Fossa cranii anterior
Medial	Sinus ethmoidalis
Inferior	Sinus maxillaris
Certain deeper structures also have a clinically important relationship to the orbita:	
Sinus sphenoidalis	Glandula pituitaria
Fossa cranii media	Sinus cavernosus
Chiasma opticum	Fossa pterygopalatina

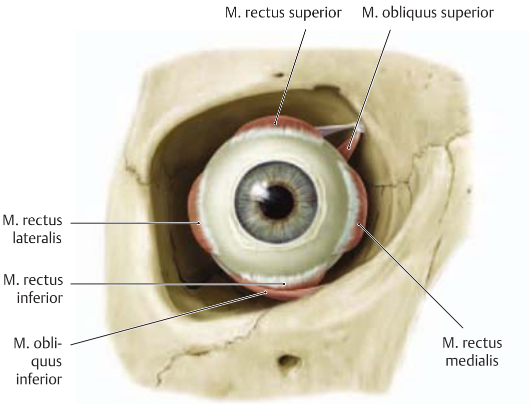


D Coronal section, anterior view.

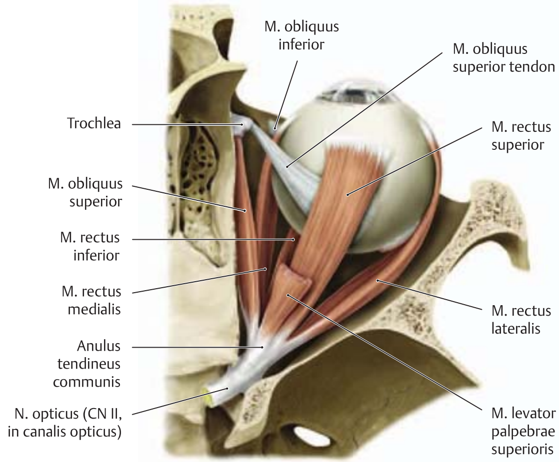
Muscles of the Orbita

Fig. 33.2 Extraocular muscles

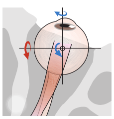
Right eye, superior view (except **A**). The eyeball is moved by six extrinsic muscles: four rectus (mm. rectus superior, inferior, medialis, and lateralis) and two oblique (mm. obliquus superior and inferior).



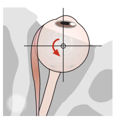
A Anterior view.



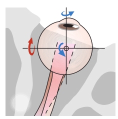
B Superior view of opened orbita.



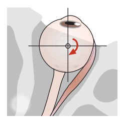
C M. rectus superior.



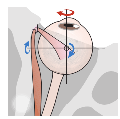
D M. rectus medialis.



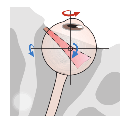
E M. rectus inferior.



F M. rectus lateralis.



G M. obliquus superior.



H M. obliquus inferior.

Table 33.3 **Extraocular muscles**

Muscle	Origin	Insertion	Primary action (red)	Secondary action (blue)	Innervation
M. rectus superior	Anulus tendineus communis	Sclera of the eye	Elevation	Adduction and medial rotation	N. oculomotorius (CN III), r. superior
M. rectus medialis			Adduction	—	N. oculomotorius (CN III), r. inferior
M. rectus inferior			Depression	Adduction and lateral rotation	
M. rectus lateralis			Abduction	—	N. abducens (CN VI)
M. obliquus superior	Os sphenoidale*		Depression and abduction	Medial rotation	N. trochlearis (CN IV)
M. obliquus inferior	Margo orbitalis medialis		Elevation and abduction	Lateral rotation	N. oculomotorius (CN III), r. inferior

* The tendon of insertion of the m. obliquus superior passes through a tendinous loop (trochlea) attached to the margo orbitalis superomedialis.

Fig. 33.3 Cardinal directions of gaze

There are six cardinal directions of gaze, all of which are tested during clinical evaluation of ocular motility. *Note:* Each gaze requires activation of two different muscles (not a muscle pair) and therefore two cranial nerves.

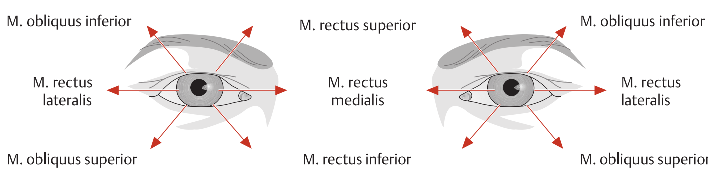
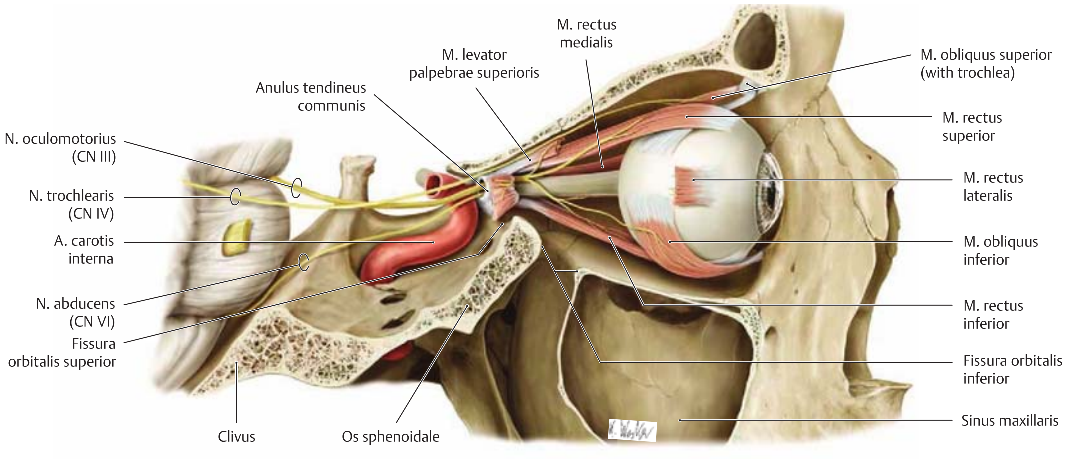


Fig. 33.4 **Innervation of the extraocular muscles**
Right eye, lateral view with the temporal wall of the orbita removed.

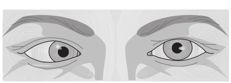


Clinical

N. oculomotorius palsies

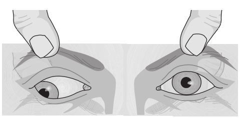
N. oculomotorius palsies may result from a lesion involving an eye muscle or its associated cranial nerve (at the nucleus or along the course of the nerve). If one extraocular muscle is weak or paralyzed, deviation of the eye will be noted.

Impairment of the coordinated actions of the extraocular muscles may cause the visual axis of one eye to deviate from its normal position. The patient will therefore perceive a double image (diplopia).

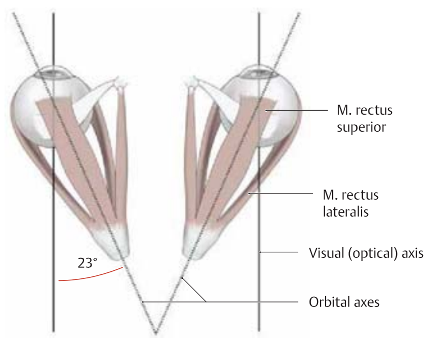


A N. abducens palsy. *Disabled:* M. rectus lateralis.

B N. trochlearis palsy. *Disabled:* M. obliquus superior.



C Complete n. oculomotorius palsy. *Disabled:* Mm. rectus superior and inferior and m. obliquus inferior.



D Normal visual and orbital axes.

Neurovasculature of the Orbita

Fig. 33.5 Veins of the orbita
Lateral view of the right orbita. *Removed:* Lateral orbital wall. *Opened:* Sinus maxillaris.

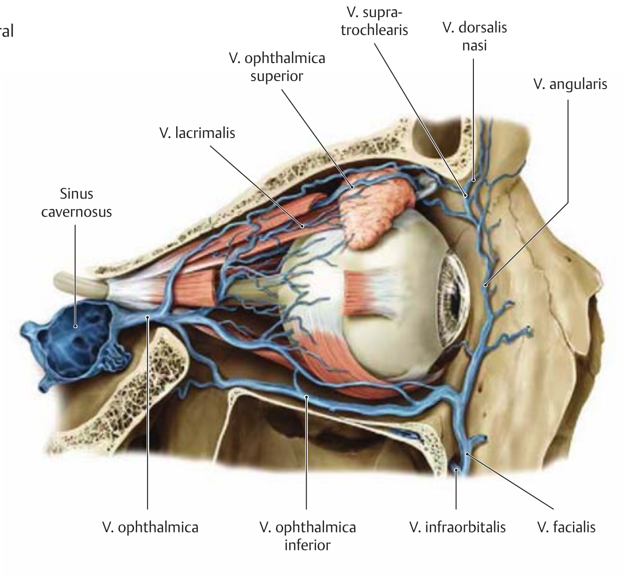


Fig. 33.6 Arteries of the orbita
Superior view of the right orbita. *Opened:* Canalis opticus and orbital roof.

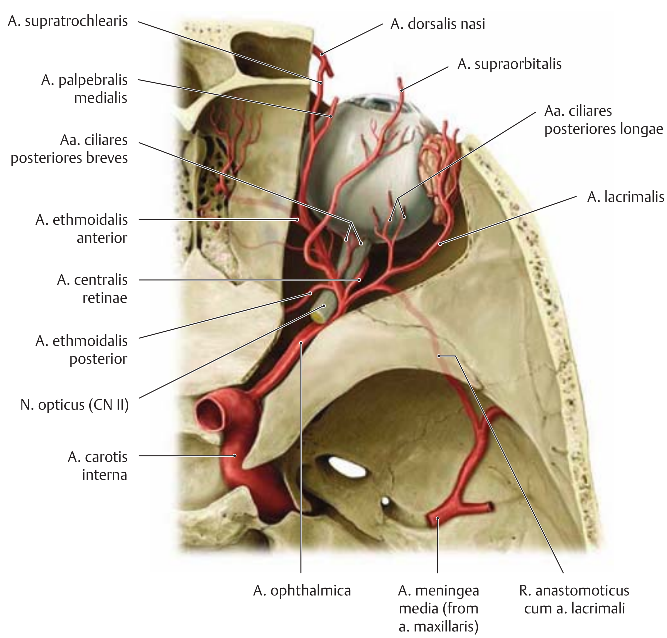


Fig. 33.7 Innervation of the orbita

Lateral view of the right orbita. *Removed:* Temporal bony wall.

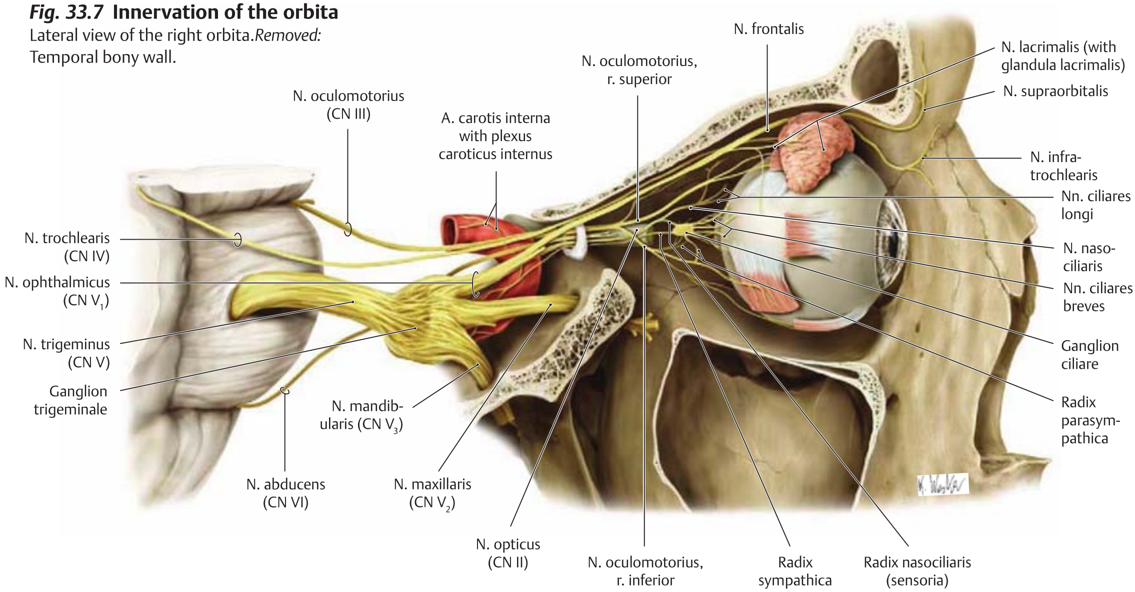
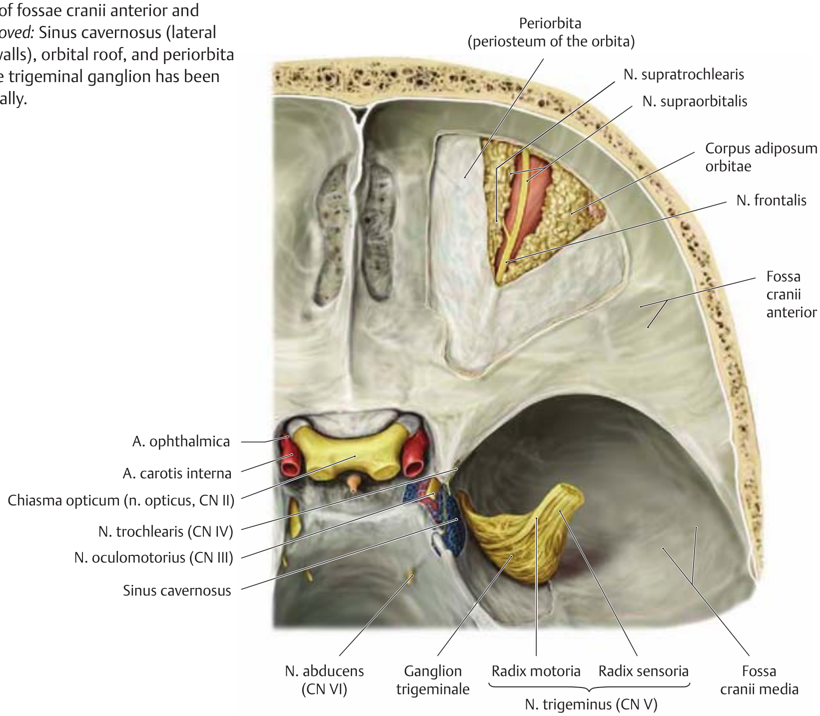


Fig. 33.8 Cranial nerves in the orbit

Superior view of fossae cranii anterior and posterior. *Removed:* Sinus cavernosus (lateral and superior walls), orbital roof, and periorbita (portions). The trigeminal ganglion has been retracted laterally.



Topography of the Orbita

Fig. 33.9 Neurovascular structures of the orbita
Anterior view. *Right side:* M. orbicularis oculi removed. *Left side:* Septum orbitale partially removed.

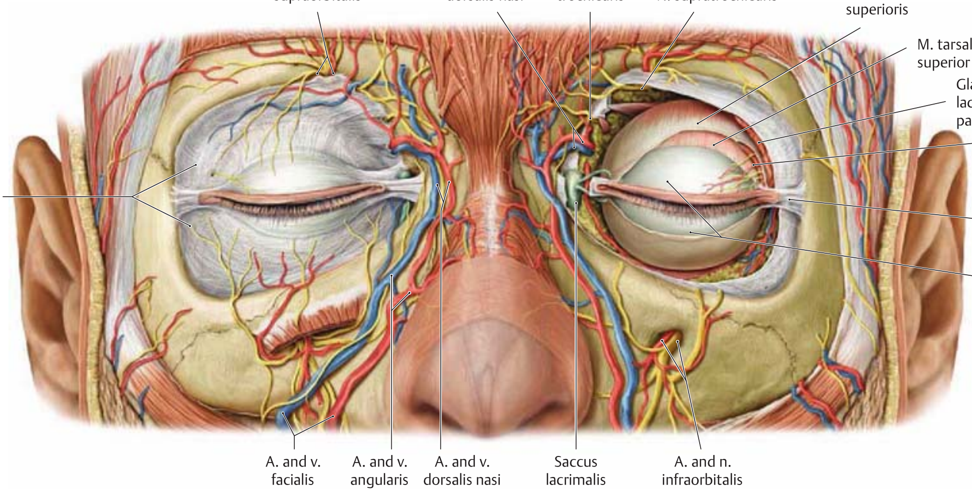


Fig. 33.10 Passage of neurovascular structures through the orbita
Anterior view. *Removed:* Orbital contents. *Note:* N. opticus and a. ophthalmica travel in canalis opticus. The remaining structures pass through fissura orbitalis superior.

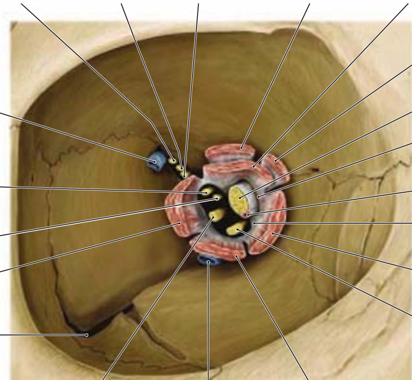
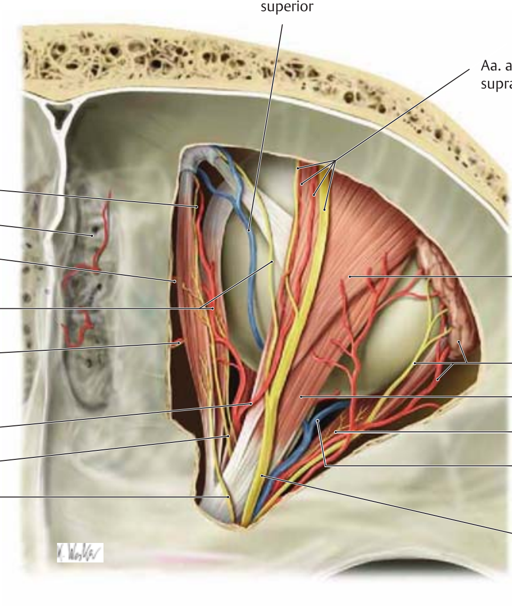
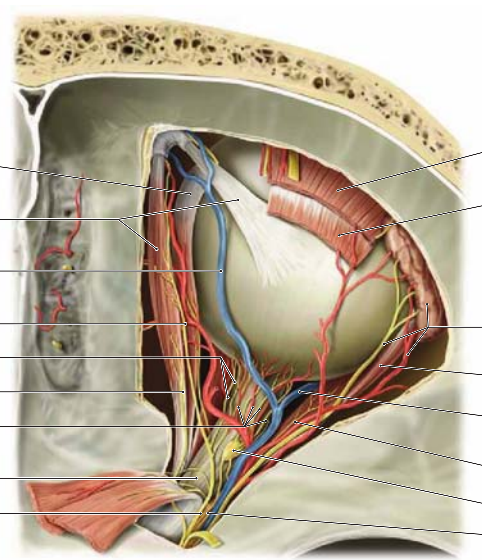


Fig. 33.11 **Neurovascular contents of the orbita**

Superior view. *Removed:* Bony roof of orbita, peritorbita, and corpus adiposum orbitae.



A Upper level.



B Middle level. *Reflected:* M. levator palpebrae superioris and m. rectus superior. *Revealed:* N. opticus.

Orbita & Eyelid

Fig. 33.12 **Topography of the orbita**
Sagittal section through the right orbita, medial view.

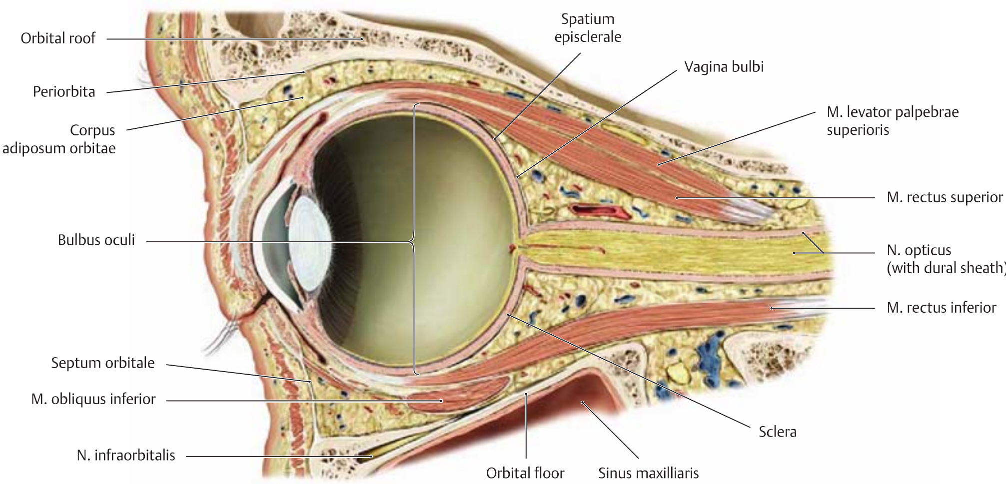


Fig. 33.13 **Eyelids and tunica conjuctiva**
Sagittal section through the anterior orbital cavity.

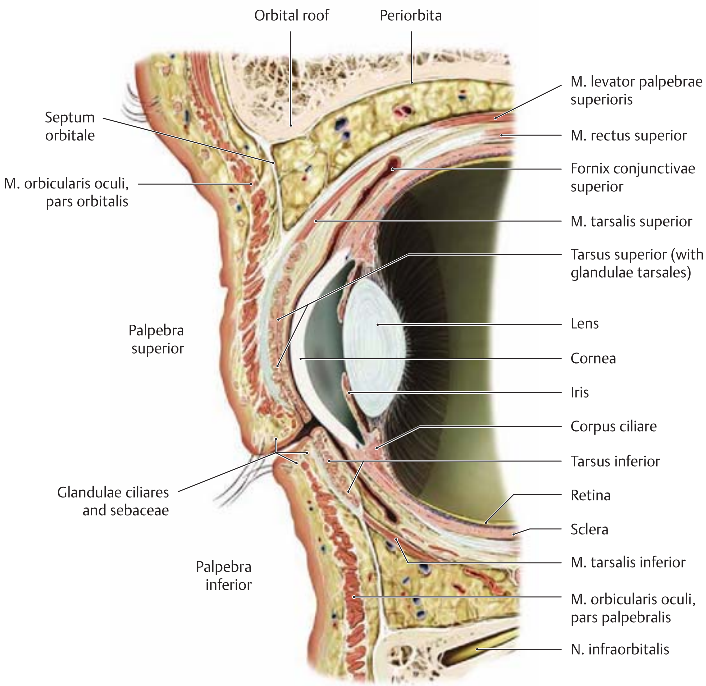
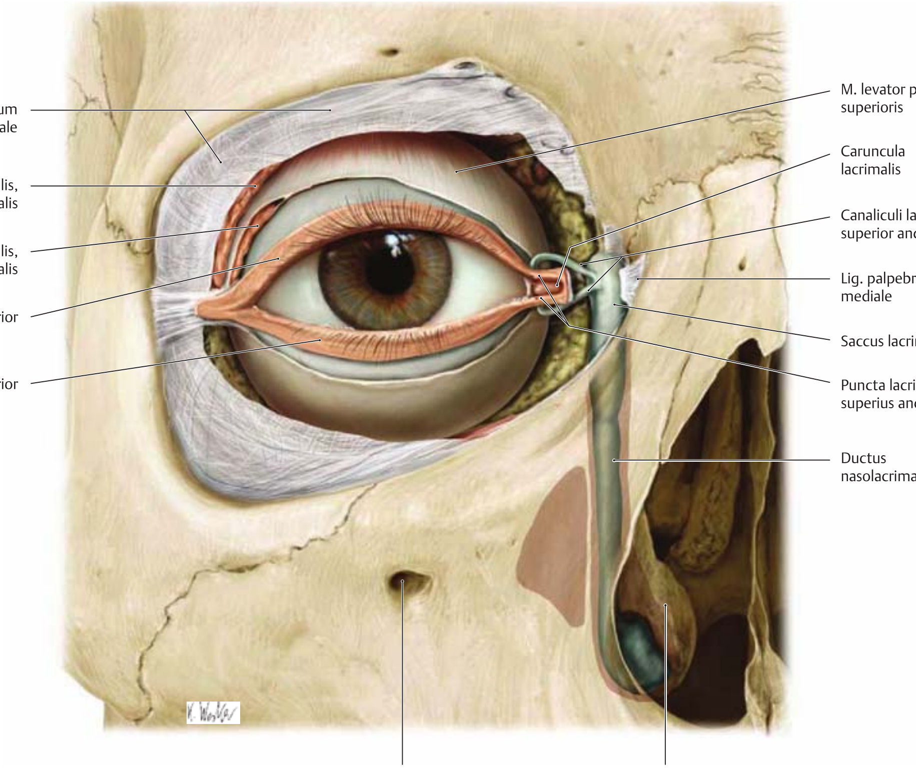


Fig. 33.14 Lacrimal apparatus
Right eye, anterior view. *Removed:* Orbital septum (partial). *Divided:* M. levator palpebrae superioris (tendon of insertion).

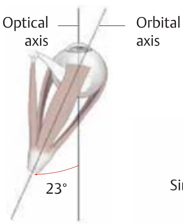


Clinical

Lacrimal drainage
Perimenopausal women are frequently subject to chronically dry eyes (*keratoconjunctivitis sicca*), due to insufficient tear production by the glandula lacrimalis. Acute inflammation of the glandula lacrimalis (due to bacteria) is less common and characterized by intense inflammation and extreme tenderness to palpation. The upper eyelid shows a characteristic S-curve.

Eyeball (Bulbus Oculi)

Fig. 33.15 **Structure of the eyeball (bulbus oculi)**
Transverse section through right eyeball, superior view. *Note:* The orbital axis (running along n. opticus through the discus nervi optici) deviates from the optical axis (running down the center of the eye to the fovea centralis) by 23 degrees.



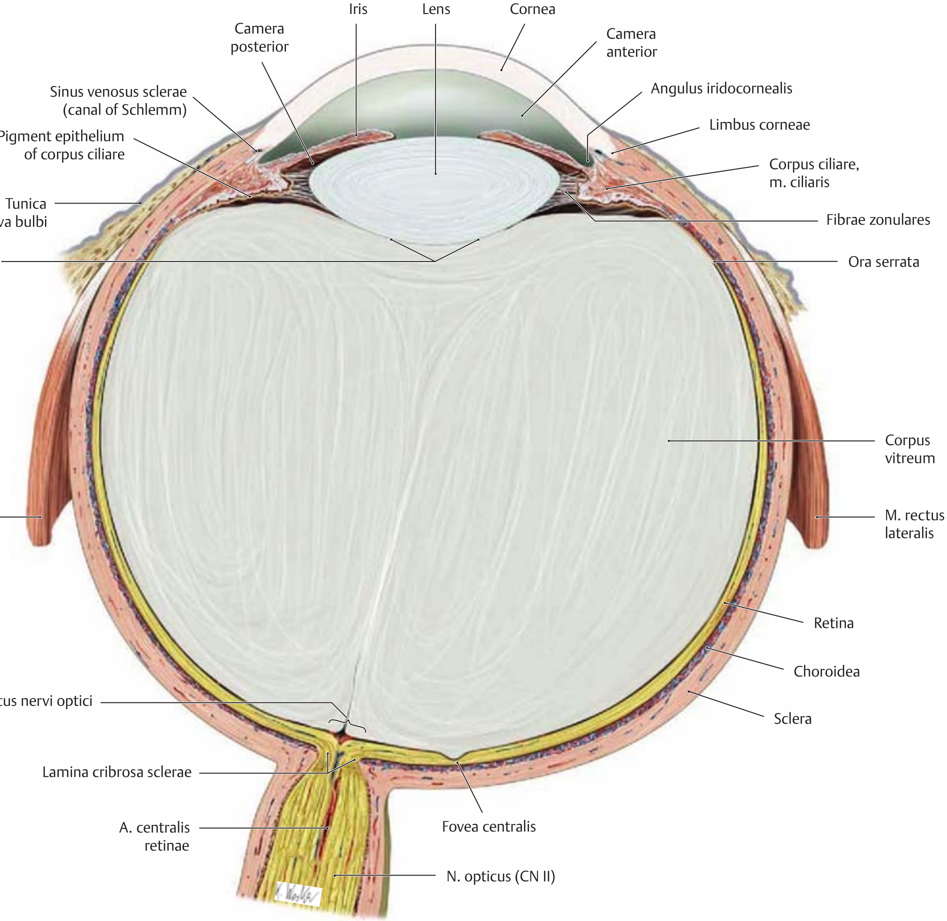
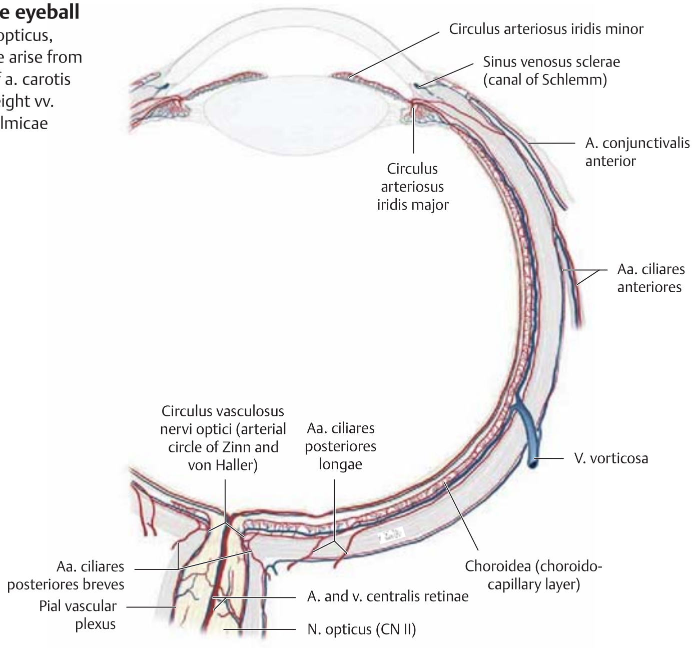
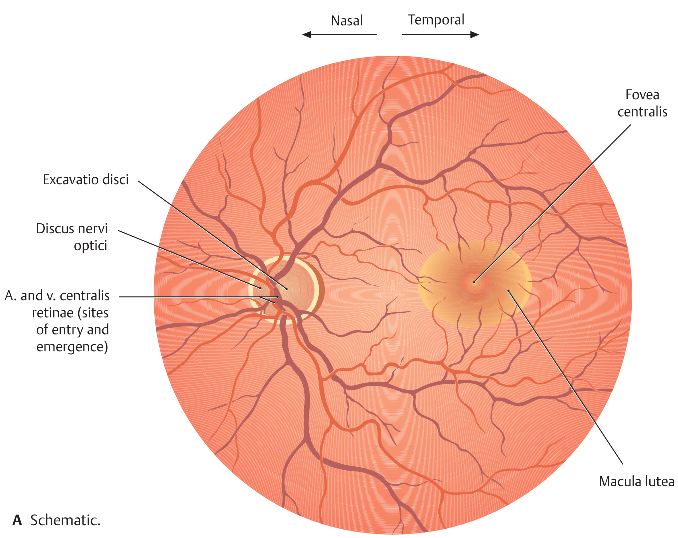


Fig. 33.16 Blood vessels of the eyeball
Transverse section at the level of n. opticus, superior view. The arteries of the eye arise from a. ophthalmica, a terminal branch of a. carotis interna. Blood is drained by four to eight vv. vorticosae that open into vv. ophthalmicae superior and inferior.

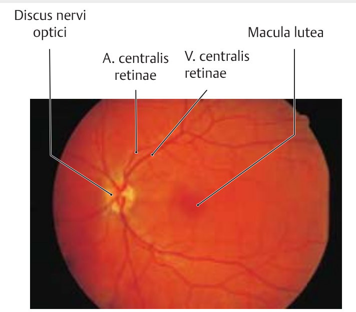


Clinical

Fundus oculi
The fundus oculi is the only place in the body where capillaries can be examined directly. Examination of fundus oculi permits observation of vascular changes that may be caused by high blood pressure or diabetes. Examination of the discus nervi optici is important in determining intracranial pressure and diagnosing multiple sclerosis.



A Schematic.



B Normal optic fundus in the ophthalmoscopic examination.

C High intracranial pressure; the edges of the optic disk appear less sharp.

Cornea, Iris & Lens

***Fig. 33.17* Cornea, iris, and lens**
Transverse section through the anterior segment of the eye. Anterosuperior view.

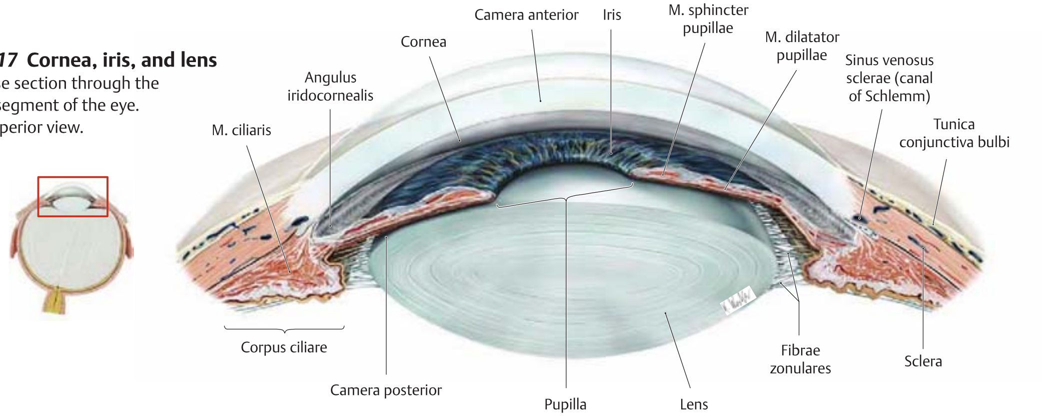
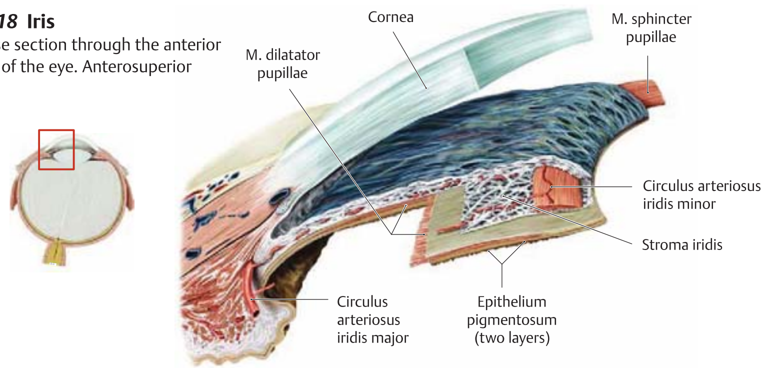


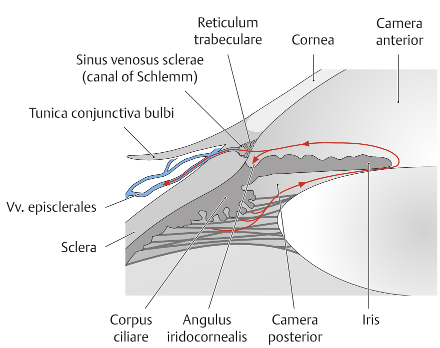
***Fig. 33.18* Iris**
Transverse section through the anterior segment of the eye. Anterosuperior view.



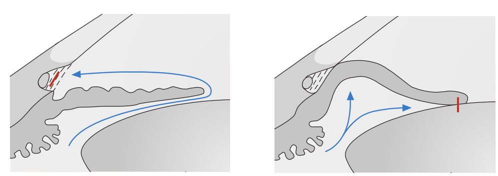
Clinical

Glaucoma

Aqueous humor produced in the camera posterior passes through the pupil into the camera anterior. It seeps through the spaces of the reticulum trabeculare into the sinus venosus sclerae (canal of Schlemm) before passing into the vv. episclerales. Obstruction of aqueous humor drainage causes an increase in intraocular pressure (glaucoma), which constricts n. opticus in the lamina cribrosa sclerae. This constriction eventually leads to blindness. The most common glaucoma (approximately 90% of cases) is chronic (open-angle) glaucoma. The more rare acute glaucoma is characterized by red eye, strong headache and/or eye pain, nausea, dilated episcleral veins, and edema of the cornea.



A Normal drainage.



B Chronic (open-angle) glaucoma. Drainage through the trabecular meshwork is impaired.

C Acute (angle-closure) glaucoma. The chamber angle is obstructed by iris tissue. Aqueous fluid cannot drain into the anterior chamber, which pushes portions of the iris upward, blocking the chamber angle.

Fig. 33.19 **Pupilla**
Pupilla size is regulated by two intraocular muscles of the iris: m. sphincter pupillae, which narrows the pupil (parasympathetic innervation), and m. dilator pupillae, which enlarges it (sympathetic innervation).

A Normal pupil size.

B Maximum constriction (miosis).

C Maximum dilation (mydriasis).

Fig. 33.20 **Lens and corpus ciliare**
Posterior view. The curvature of the lens is regulated by the muscle fibers (m. ciliaris) of the annular corpus ciliare.

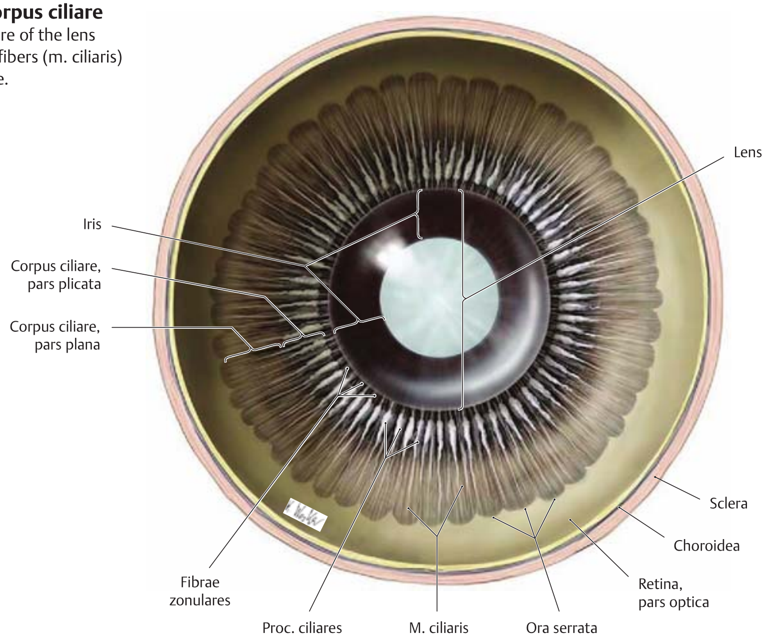
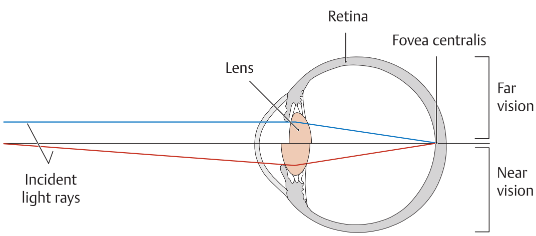
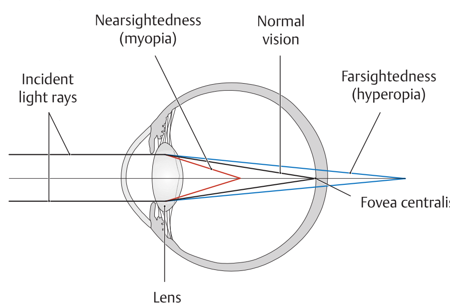


Fig. 33.21 **Light refraction by the lens**
Transverse section, superior view. In the normal (emmetropic) eye, light rays are refracted by the lens (and cornea) to a focal point on the retinal surface (fovea centralis). Tensing of the fibrae zonulares, with relaxation of the m. ciliaris, flattens the lens in response to parallel rays arriving from a distant source (far vision). Contraction of m. ciliaris, with relaxation of fibrae zonulares, causes the lens to assume a more rounded shape (near vision).



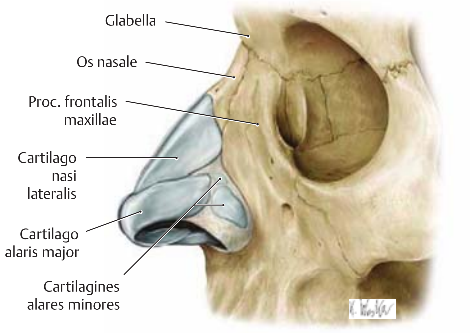
A Normal dynamics of the lens.



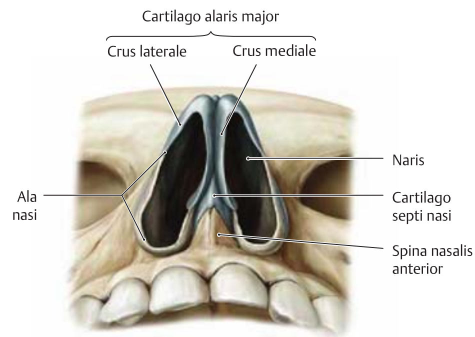
B Abnormal lens dynamics.

Bones of the Nasal Cavity (Cavitas Nasi)

Fig. 34.1 **Skeleton of the nose**
The skeleton of the nose is composed of an upper bony portion and a lower cartilaginous portion. The proximal portions of the nostrils (alae) are composed of connective tissue with small embedded pieces of cartilage.

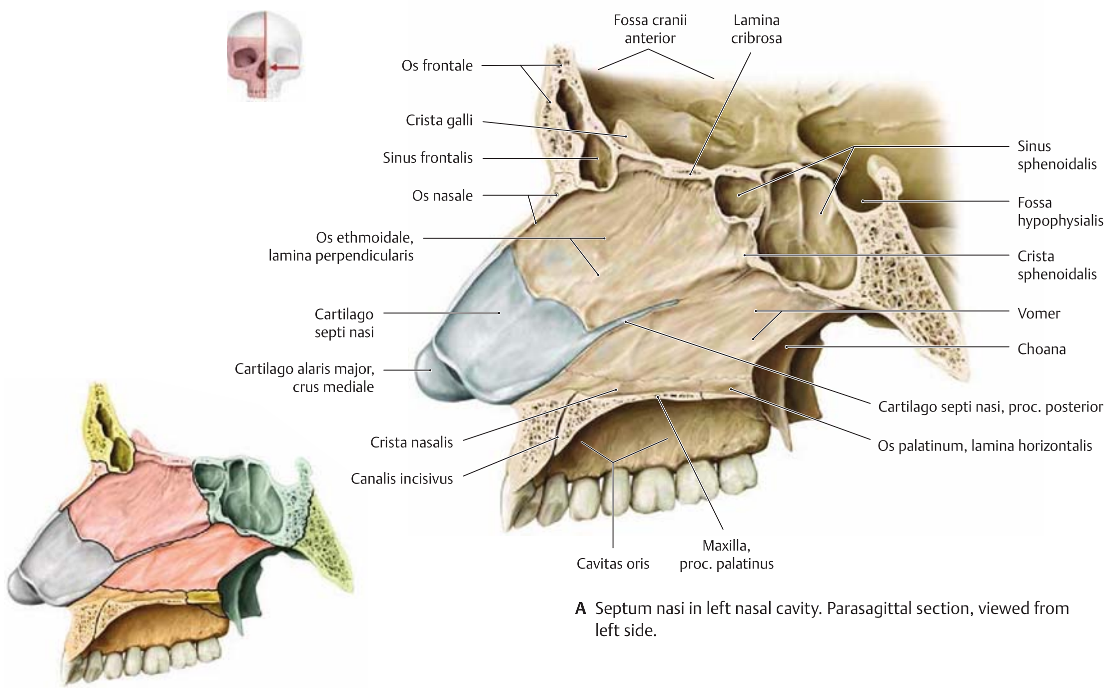


A Left lateral view.

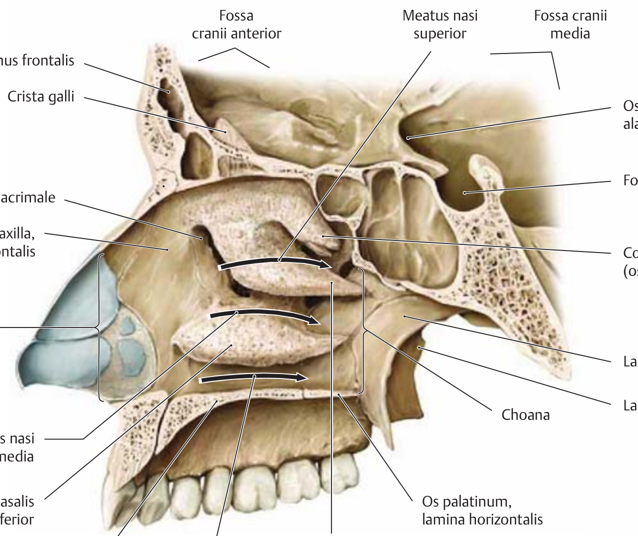


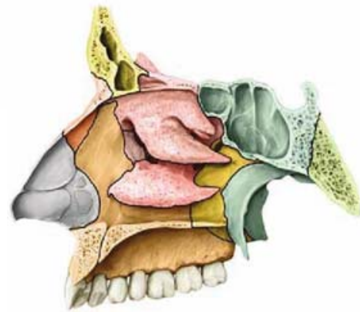
B Inferior view.

Fig. 34.2 **Bones of the nasal cavity (cavitas nasi)**
The left and right nasal cavities are flanked by lateral walls and separated by septum nasi. Air enters the nasal cavity through the anterior nasal aperture and travels through three passages: the meatus nasi superior, medius, and inferior (arrows). These passages are separated by the superior, media, and inferior conchae nasi. Air leaves the nose through the choanae, entering the nasopharynx.

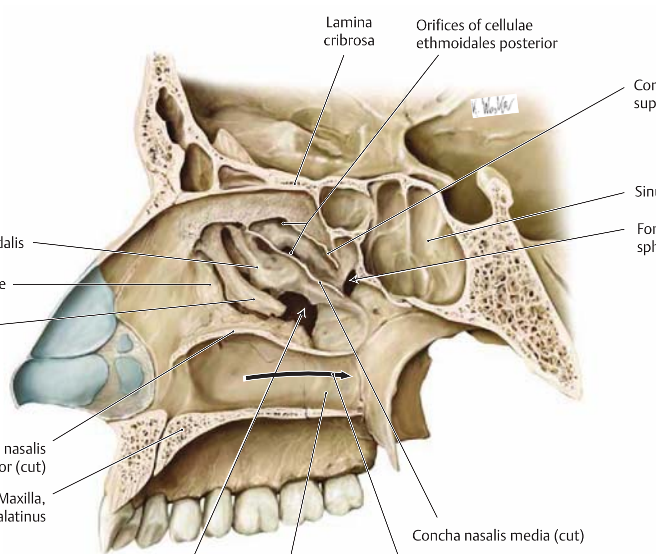


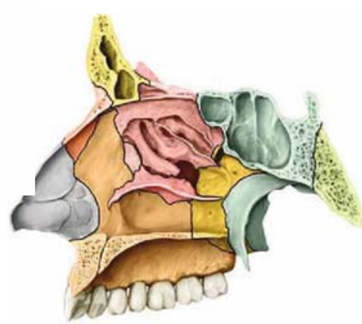
A Septum nasi in left nasal cavity. Parasagittal section, viewed from left side.





B Lateral wall of the right nasal cavity. Sagittal section, medial view. *Removed:* Septum nasi. *Note:* The conchae nasi superior and media are parts of os ethmoidale, whereas the concha nasi inferior is a separate bone.



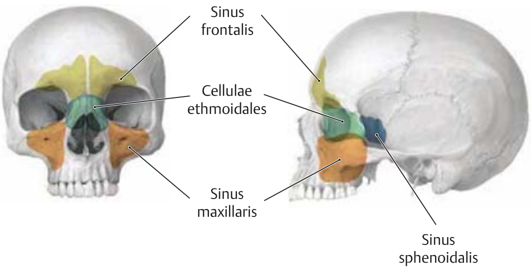


C Lateral wall of the right nasal cavity with the conchae removed. Sagittal section, medial view. *Revealed:* Sinus paranasales (p. 522).

Paranasal Air Sinuses (Sinus Paranasales)

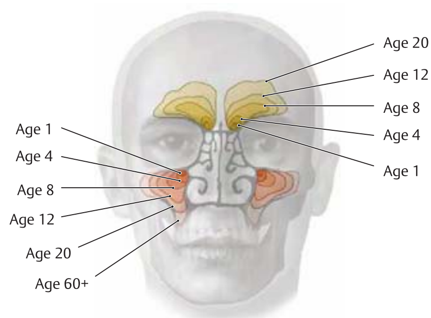
Fig. 34.3 Location of the paranasal sinuses

The paranasal sinuses [sinus frontalis, sinus (cellulae) ethmoidalis, sinus maxillaris, and sinus sphenoidalis] are air-filled cavities that reduce the weight of the skull.



A Anterior view.

B Left lateral view.



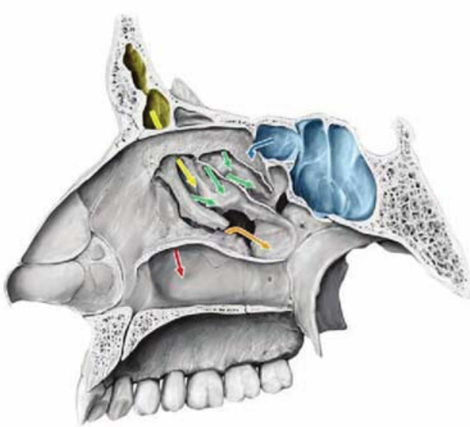
C Pneumatization of the sinuses. Sinus frontalis and maxillaris develop gradually over the course of cranial growth.

Table 34.1 Opening of nasal structures into the nose

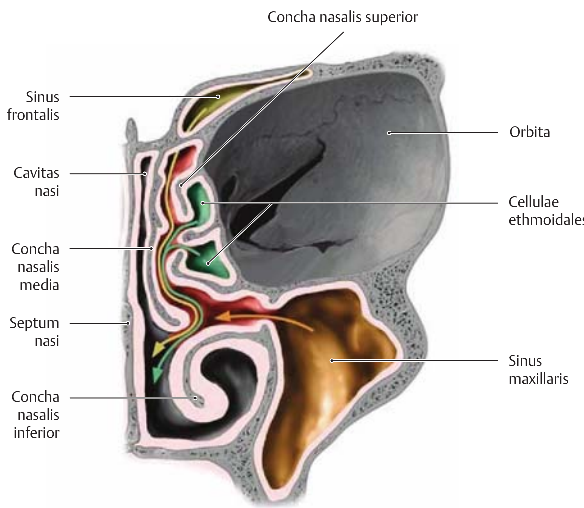
Nasal passage	Sinuses/duct
Recessus sphenoethmoidalis	Sinus sphenoidalis (blue)
Meatus nasi superior	Sinus ethmoidalis posterior (green)
Meatus nasi medius	Sinus ethmoidalis anterior and medius (green)
	Sinus frontalis (yellow)
	Sinus maxillaris (orange)
Meatus nasi inferior	Ductus nasolacrimalis (red)

Fig. 34.4 Paranasal sinuses

Mucosal secretions from the sinuses and ductus nasolacrimalis open into the nose.



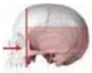
A Openings of the paranasal sinuses and ductus nasolacrimalis. Sagittal section, medial view of the right nasal cavity.

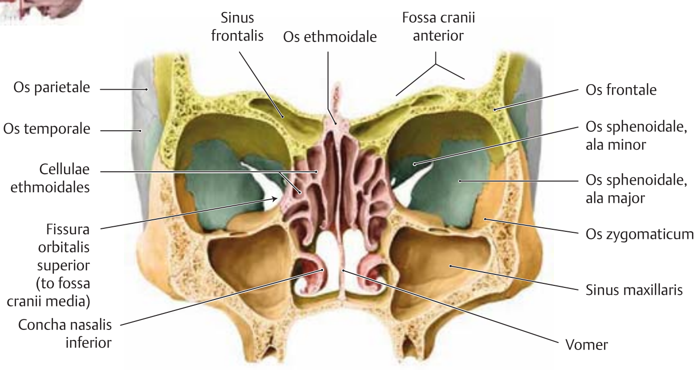


B Paranasal sinuses and osteomeatal unit in the left nasal cavity. Coronal section, anterior view.

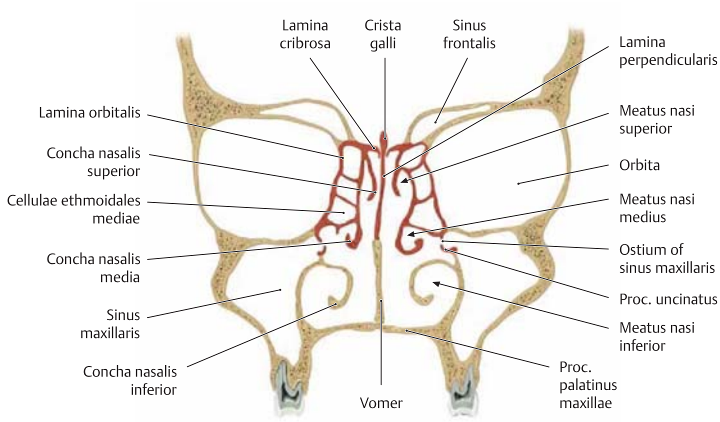
Fig. 34.5 Bony structure of the paranasal sinuses

Coronal section, anterior view.





A Bones of the paranasal sinuses.



B Os ethmoidale (red) in the paranasal sinuses.

C MRI through the paranasal sinuses.

Clinical

Deviated septum

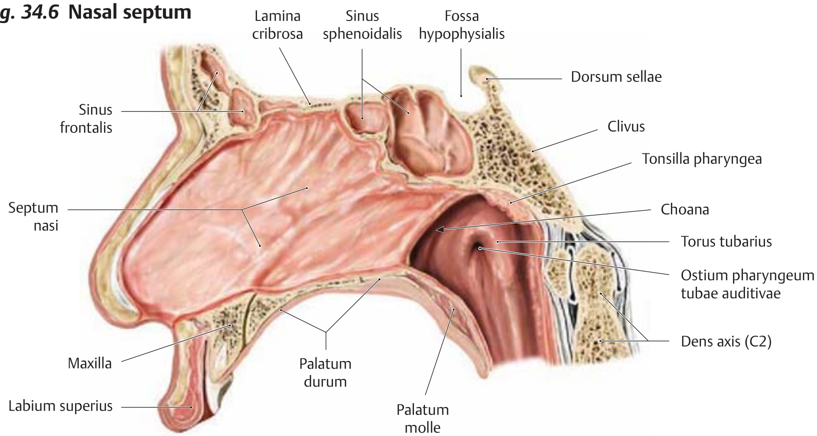
The normal position of septum nasi creates two roughly symmetrical nasal cavities. Extreme lateral deviation of the septum may result in obstruction of the nasal passages. This may be corrected by removing portions of the cartilage (septoplasty).

Sinusitis

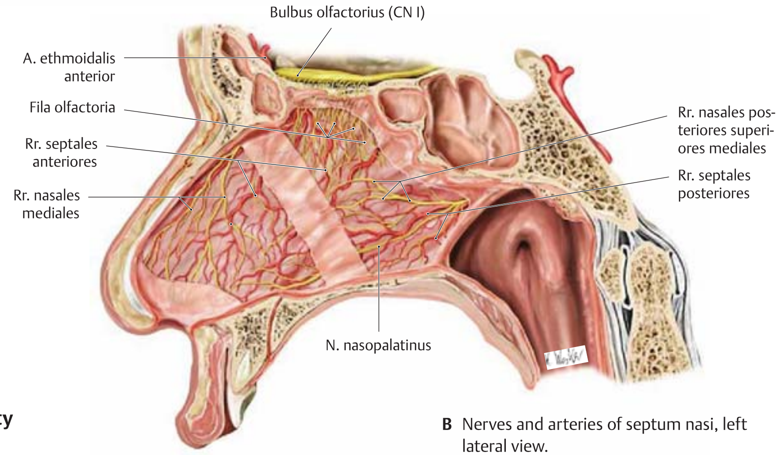
When the mucosa in cellulae ethmoidales becomes swollen due to inflammation (*sinusitis*), it blocks the flow of secretions from sinus frontalis and maxillaris in the osteomeatal unit (see Fig. 34.4). This may cause microorganisms to become trapped, causing secondary inflammations. In patients with chronic sinusitis, the narrow sites can be surgically widened to establish more effective drainage routes.

Neurovasculature of the Nasal Cavity

Fig. 34.6 Nasal septum

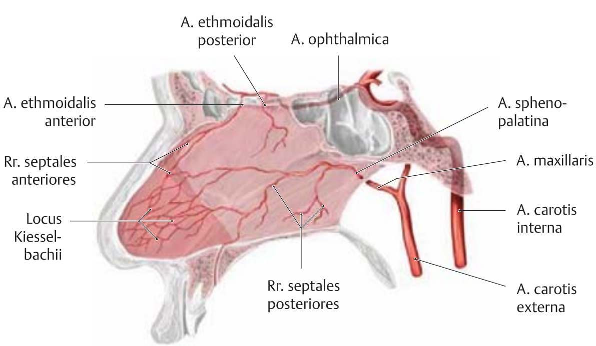


A Mucosa of septum nasi. Parasagittal section, viewed from the left side.

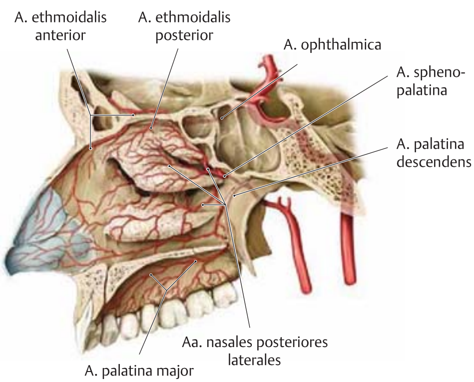


B Nerves and arteries of septum nasi, left lateral view.

Fig. 34.7 Arteries of the nasal cavity
Left lateral view. *Note:* The venous drainage of the nasal cavity is into the v. facialis and vv. ophthalmicae.

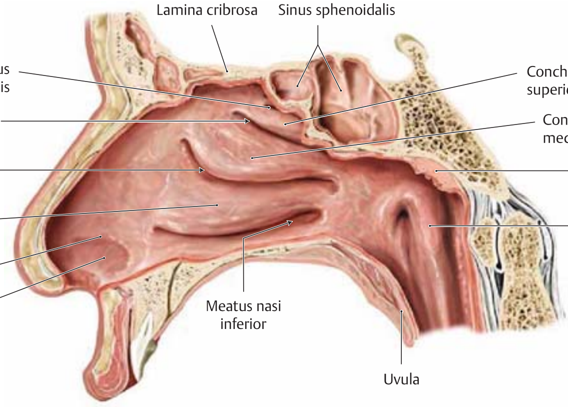


A Arteries of septum nasi.

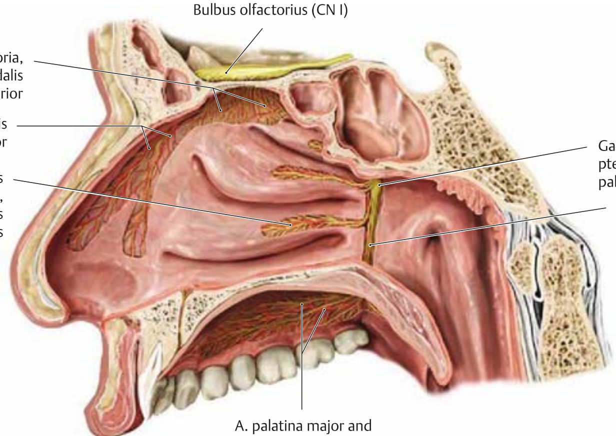


B Arteries of the right lateral nasal wall.

Fig. 34.8 **Lateral nasal wall**



A Mucosa of the lateral nasal wall. Sagittal section, viewed from the left side.



B Nerves and arteries of the lateral nasal wall, left lateral view.

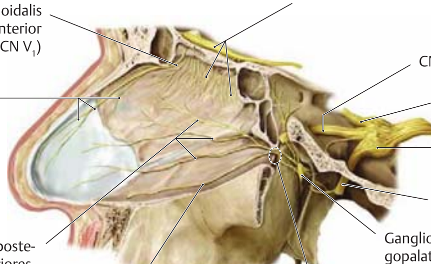
Clinical

Nosebleeds

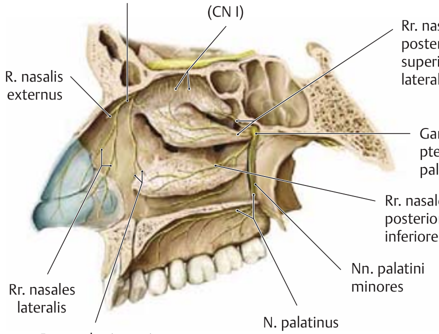
Vascular supply to the nasal cavity arises from both aa. carotis interna and externa. The anterior part of septum nasi contains a very vascularized region referred to as Locus Kiesselbachii. This area is the most common site of significant nosebleeds.

Fig. 34.9 **Nerves of the nasal cavity**

Left lateral view.



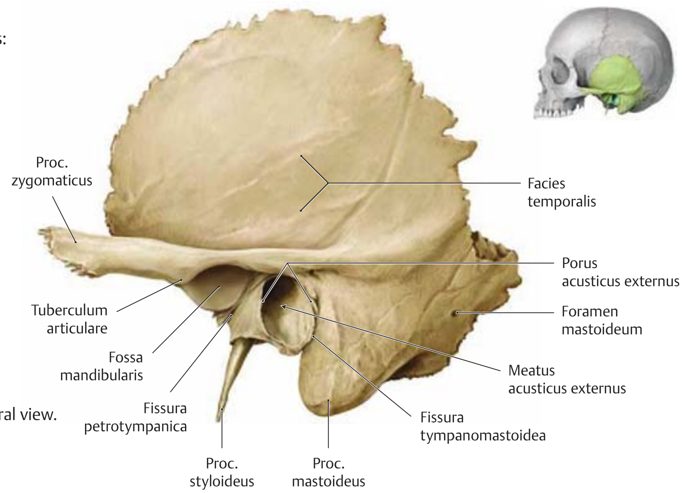
A Nerves of septum nasi.



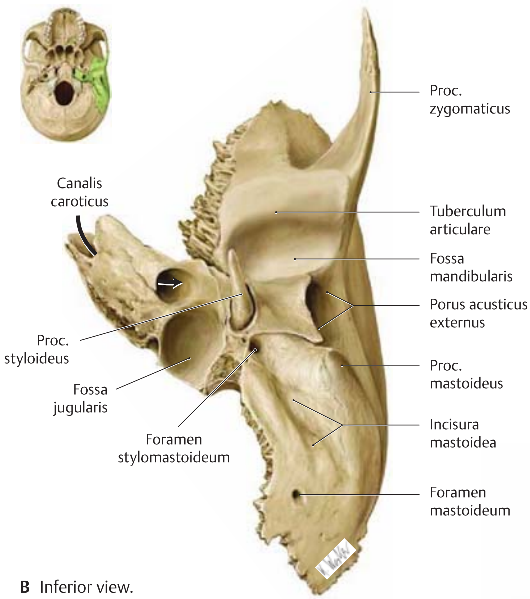
B Nerves of the lateral nasal wall.

Os Temporale

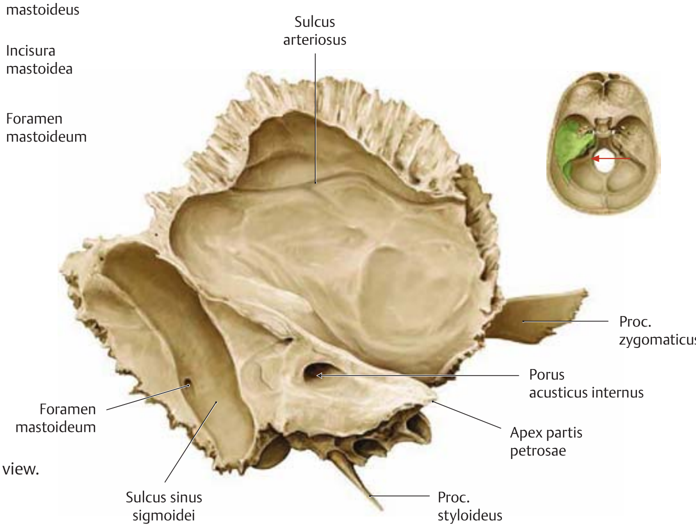
***Fig. 35.1* Os temporale**
Left bone. The os temporale consists of three major parts: pars squamousa, pars petrosa, and pars tympanica (see Fig. 35.2).



A Left lateral view.

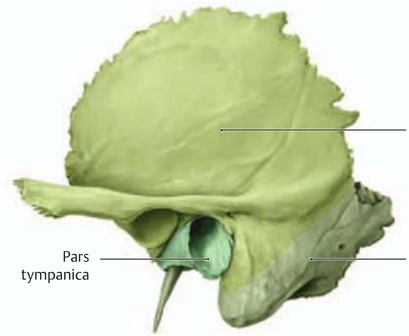


B Inferior view.

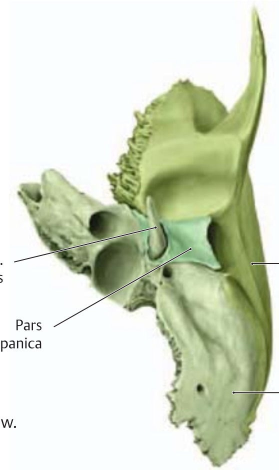


C Medial view.

Fig. 35.2 **Parts of os temporale**



A Left lateral view.

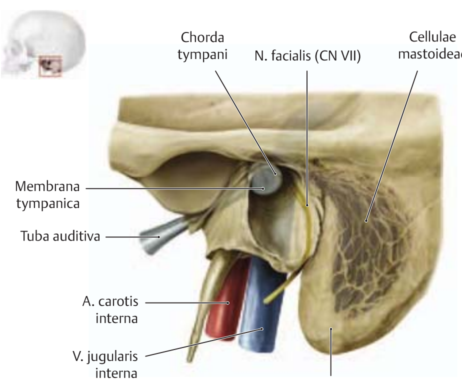


B Inferior view.

Clinical

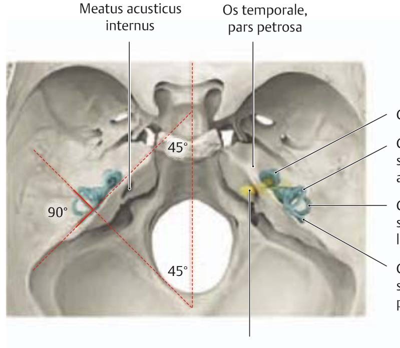
Structures in os temporale

The processus mastoideus contains mastoid air cells (cellulae mastoideae) that communicate with the middle ear; the middle ear in turn communicates with the nasopharynx via the tuba auditiva. Bacteria may use this pathway to move from the nasopharynx into the middle ear. In severe cases, bacteria may pass from the mastoid air cells into the cranial cavity, causing meningitis.



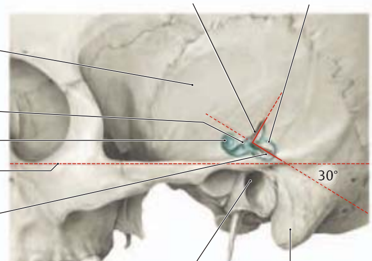
A

Irrigation of the auditory canal with warm (44°C) or cool (30°C) water can induce a thermal current in the endolympha of the canalis semicircularis, causing the patient to manifest vestibular nystagmus (jerky eye movements, vestibulo-ocular reflex). This caloric testing is important in the diagnosis of unexplained vertigo. The patient must be oriented so that the canalis semicircularis of interest lies in the vertical plane.



B

The pars petrosa of os temporale contains the middle and inner ear as well as the membrana tympanica. The bony canales semicirculares are oriented at an approximately 45-degree angle from the coronal, transverse, and sagittal planes.



C

External Ear (Auris Externa) & Auditory Canal

The auditory apparatus is divided into three main parts: external, middle, and inner ear. The external and middle ear are part of the sound conduction apparatus, and the inner ear is the actual organ of hearing (see p. 619). The inner ear also contains the vestibular apparatus, the organ of balance (see p. 618).

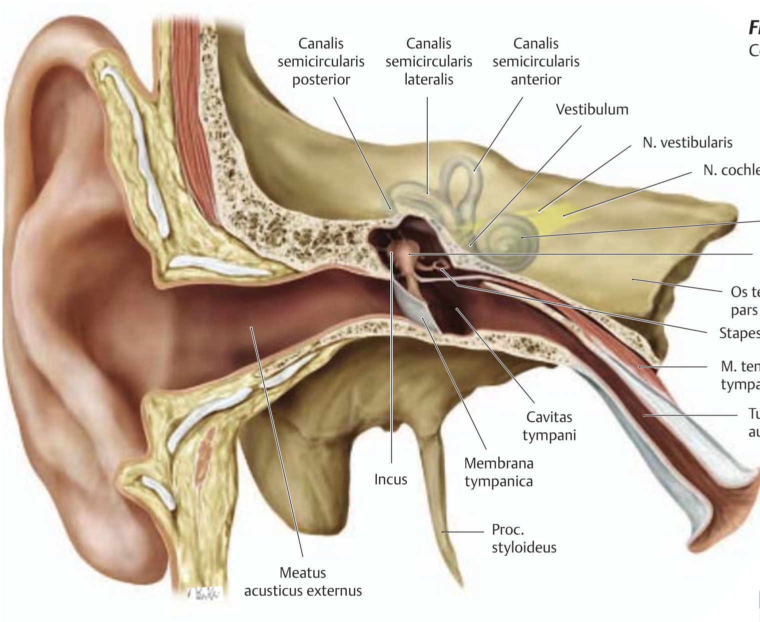
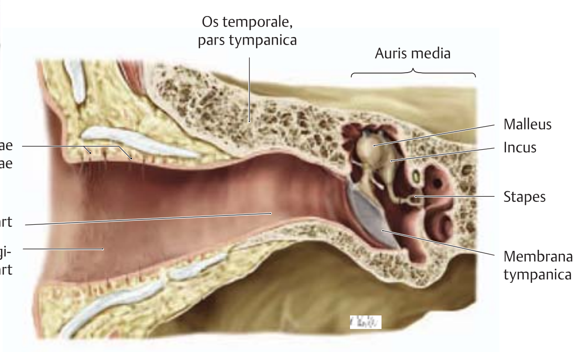


Fig. 35.3 **Ear: Overview**
Coronal section through right ear, anterior view.

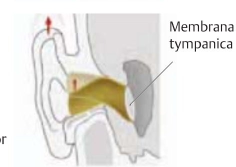
Fig. 35.4 **Meatus acusticus externus**
Coronal section through right ear, anterior view. The membrana tympanica separates the meatus acusticus externus from the cavitas tympani (middle ear). The outer third of the meatus acusticus externus is cartilaginous, and the inner two thirds are osseous (pars tympanica of os temporale).



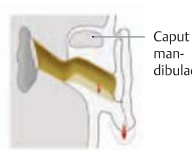
Clinical

Curvature of the meatus acusticus externus
The meatus acusticus externus is most curved in its cartilaginous portion. When an otoscope is being inserted, the auricula should be pulled backward and upward so the speculum can be introduced into a straightened canal.

A Insertion of otoscope.



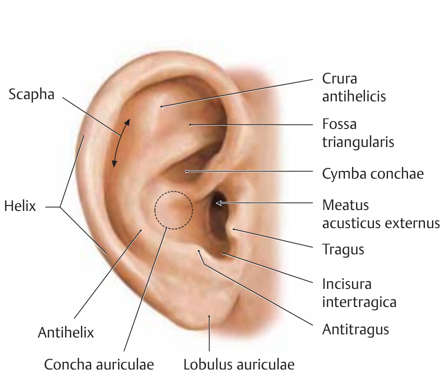
B Anterior view.



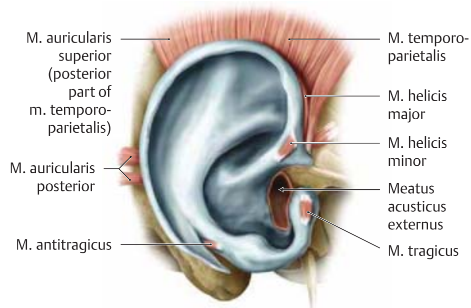
C Transverse section.

Fig. 35.5 **Structure of the auricula**

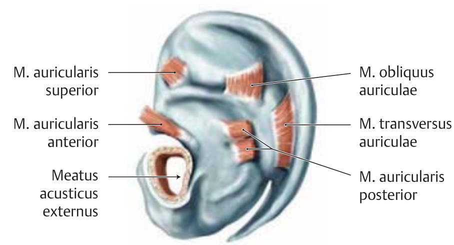
The auricula of the ear encloses a cartilaginous framework that forms a funnel-shaped receptor for acoustic vibrations. The muscles of the auricula are considered muscles of facial expression, although they are vestigial in humans.



A Right auricula, right lateral view.

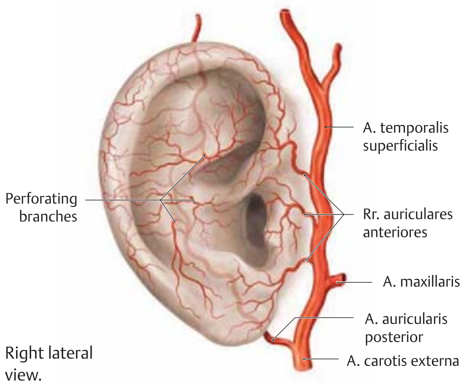


B Cartilage and muscles of the auricula, right lateral view.

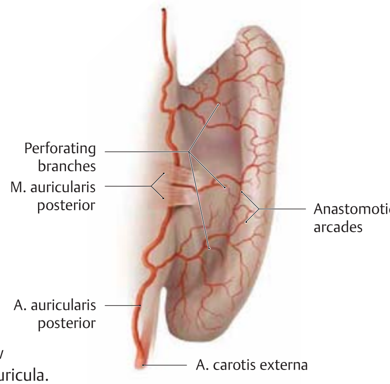


C Cartilage and muscles of the auricula, medial view of posterior surface.

Fig. 35.6 **Arteries of the auricula**

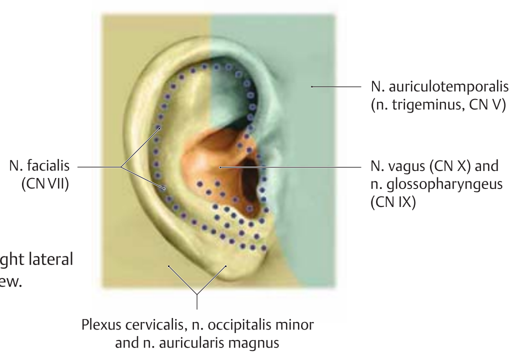


A Right lateral view.

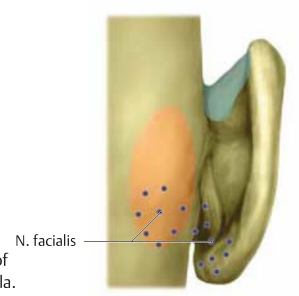


B Posterior view of the right auricula.

Fig. 35.7 **Innervation of the auricula**



A Right lateral view.



B Posterior view of the right auricula.

Middle Ear (Auris Media): Tympanic Cavity (Cavitas Tympani)

Fig. 35.8 **Middle ear**
Right pars petrosa, superior view. The tympanic cavity of the middle ear communicates anteriorly with the pharynx via the tuba auditiva and posteriorly with the cellulae mastoideae.

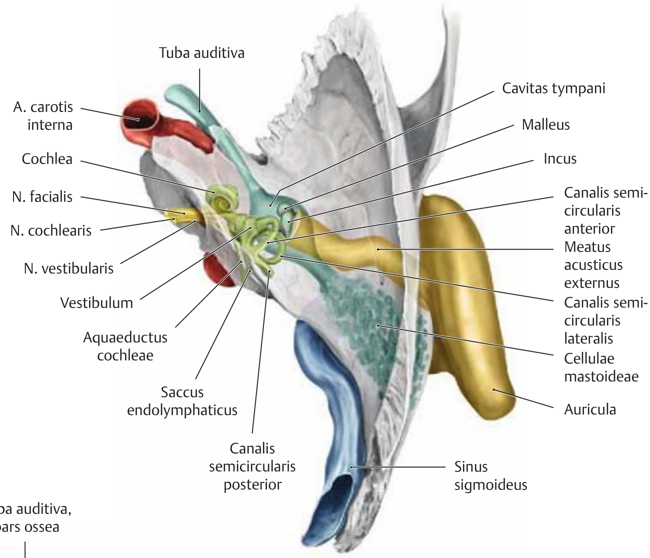


Fig. 35.9 **Tympanic cavity and tuba auditiva**
Medial view of opened tympanic cavity.

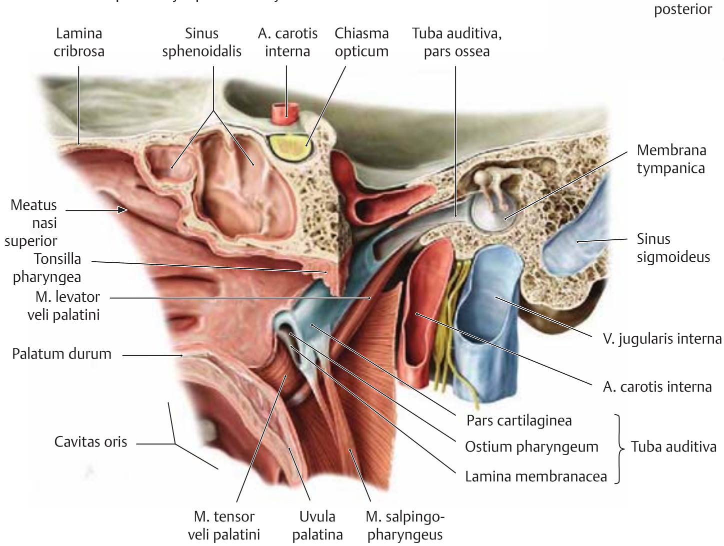


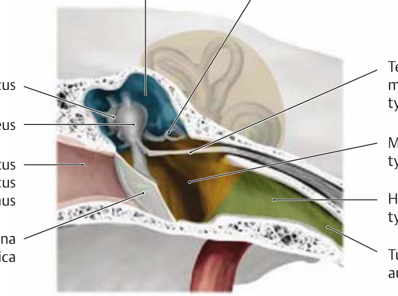
Table 35.1 **Boundaries of the Cavitas tympani**

During chronic suppurative otitis media (inflammation of the middle ear), pathogenic bacteria may spread to adjacent regions.

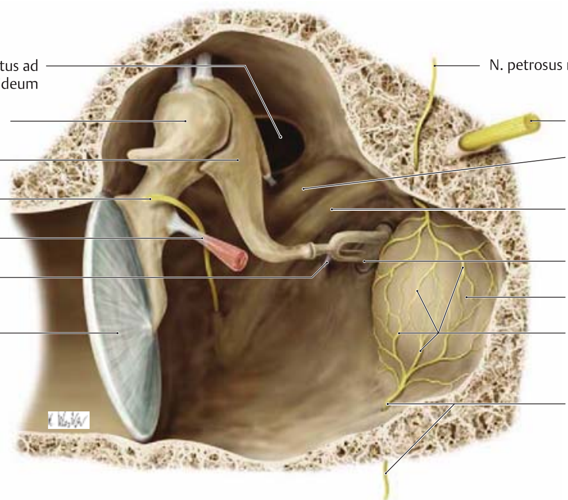
Direction	Wall	Anatomical boundary	Neighboring structures	Infection
Anterior	Carotid	Opening to tuba auditiva	Canalis caroticus	
Lateral	Paries caroticus	Membrana tympanica	Meatus acusticus externus	
Superior	Paries tegmentalis	Tegmen tympani	Fossa cranii media	Meningitis, cerebral abscess (especially of temporal lobe)
Medial	Paries labyrinthicus	Prominentia canalis semicircularis lateralis	Inner ear	
			CSF space (via petrous apex)	Abducent paralysis, trigeminal nerve irritation, visual disturbances (Gradenigo's syndrome)
Inferior	Paries jugularis	Os temporale, pars tympanica	Bulbus superior v. jugularae	
			Sinus sigmoideus	Sinus thrombosis
Posterior	Paries mastoidea	Antrum mastoideum	Cellulae mastoideae	Mastoiditis
			Canalis n. facialis	Facial paralysis

CSF = cerebrospinal fluid.

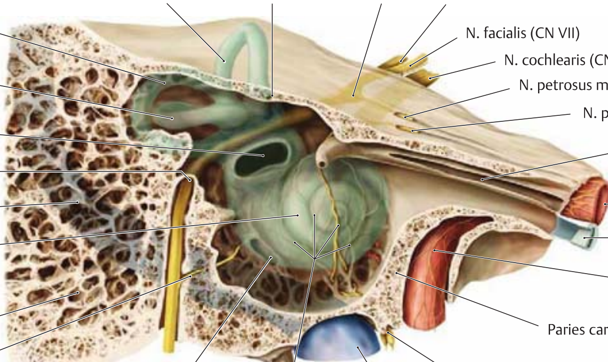
Fig. 35.10 Tympanic cavity (cavitas tympani)



A Levels of the tympanic cavity. Anterior view. The tympanic cavity is divided into three levels: epi-, meso-, and hypotympanum.



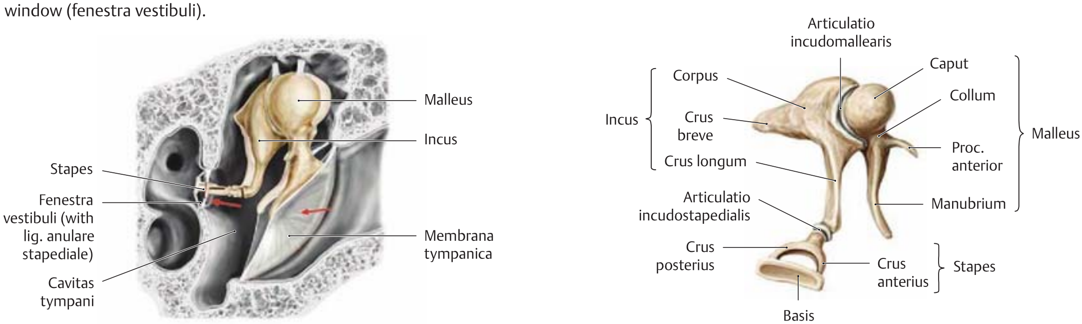
B Right tympanic cavity. Anterior view with the anterior wall removed.



C Anatomical relationships of the tympanic cavity. Oblique sagittal section showing the medial wall.

Middle Ear: Ossicular Chain & Membrana Tympanica

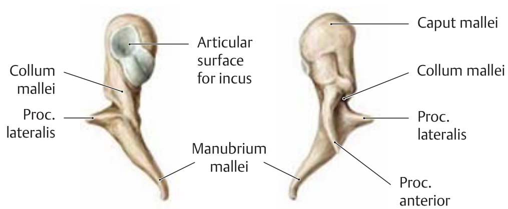
Fig. 35.11 **Auditory ossicles (ossicula auditus)**
Left ear. The ossicular chain consists of three small bones that establish an articular connection between membrana tympanica and the oval window (fenestra vestibuli).



A Auditory ossicles in the middle ear. Anterior view of the left ear.

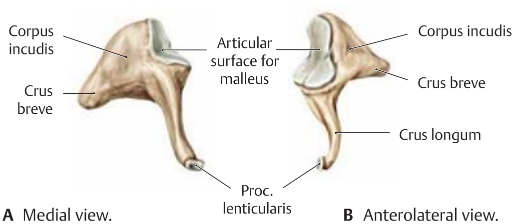
B Bones of the ossicular chain. Medial view of the left ossicular chain.

Fig. 35.12 **Malleus ("hammer")**
Left ear.



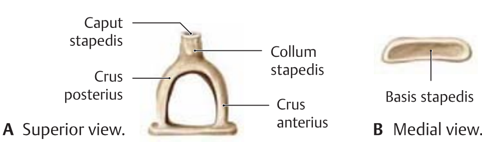
A Posterior view. **B** Anterior view.

Fig. 35.13 **Incus ("anvil")**
Left ear.



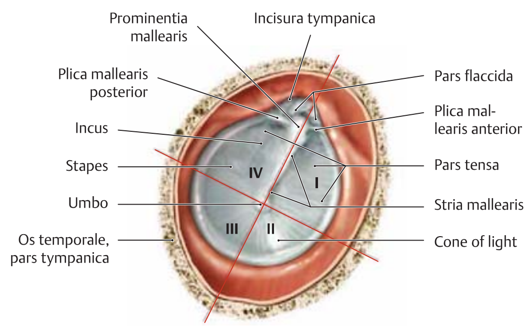
A Medial view. **B** Anterolateral view.

Fig. 35.14 **Stapes ("stirrup")**
Left ear.

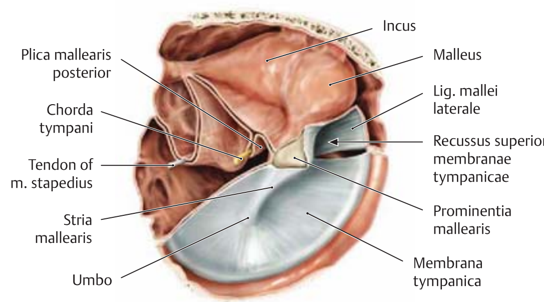


A Superior view. **B** Medial view.

Fig. 35.15 **Membrana tympanica**
Right membrana tympanica. Membrana tympanica is divided into four quadrants: anterosuperior (I), anteroinferior (II), posteroinferior (III), and posterosuperior (IV).

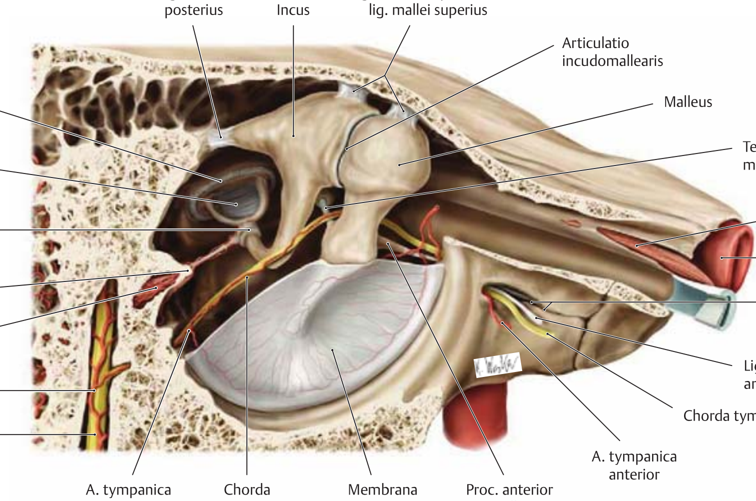


A Lateral view of the right membrana tympanica.



B Mucosal lining of the tympanic cavity. Posterolateral view with membrana tympanica partially removed.

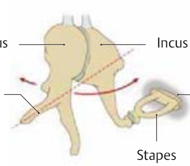
Fig. 35.16 **Ossicular chain in the tympanic cavity**
Lateral view of the right ear. *Revealed:* Ligaments of the ossicular chain and muscles of the middle ear (m. stapedius and m. tensor tympani).



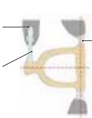
Clinical

Ossicular chain in hearing

Sound waves funneled into the meatus acusticus externus set the membrana tympanica into vibration. The ossicular chain transmits the vibrations to the oval window, which communicates them to the fluid column of the inner ear. Sound waves in fluid meet with higher impedance; they must therefore be amplified in the middle ear. The difference in surface area between membrana tympanica and the oval window increases the sound pressure 17-fold. A total amplification factor of 22 is achieved through the lever action of the ossicular chain. If the ossicular chain fails to transform the sound pressure between membrana tympanica and the basis stapedis, the patient will experience conductive hearing loss of magnitude 20 dB.See p. 619 for hearing.

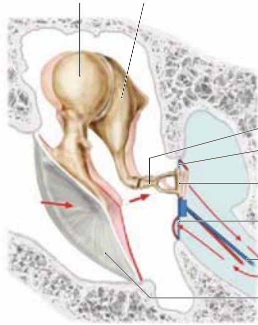


A Vibration of membrana tympanica causes a rocking movement in the ossicular chain. The mechanical advantage of the lever action of the ossicular chain amplifies the sound waves by a factor of 1.3.



B The stapes in its normal position lies in the plane of the oval window.

C Rocking of the ossicular chain causes the stapes to tilt. The movement of the basis stapedis against the membrane of the oval window (membrana stapedialis) induces corresponding waves in the fluid column of the inner ear.



D Propagation of sound waves by the ossicular chain.

Arteries of the Middle Ear

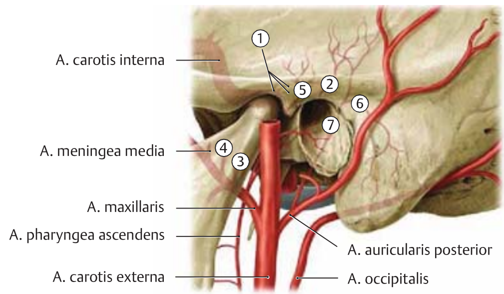


Table 35.2 Principal arteries of the middle ear

Origin	Artery			Distribution
A. carotis interna	① Aa. caroticotympanicae			Cavitas tympani (paries caroticus), tuba auditiva
A. carotis externa	A. pharyngea ascendens (r. medius)	② A. tympanica inferior		Cavitas tympani (paries jugularis), promotorium
	A. maxillaris (r. terminalis)	③ A. auricularis profunda		Cavitas tympani (paries jugularis), membrana tympanica
		④ A. tympanica anterior		Membrana tympanica, antrum mastoideum, malleus, incus
		A. meningea media	⑤ A. tympanica superior	Cavitas tympani (paries tegmentalis), m. tensor tympani, stapes
	A. auricularis posterior (r. posterior)	A. stylomastoidea	⑥ A. stylomastoidea	Cavitas tympani (paries mastoideus), cellulae mastoideae, m. stapedius, stapes
			⑦ A. tympanica posterior	Chorda tympani, membrana tympanica, malleus

Fig. 35.17 **Arteries of the middle ear: Ossicular chain and membrana tympanica**
Medial view of the right membrana tympanica. With inflammation, the arteries of membrana tympanica may become so dilated that their course can be observed (as shown here).

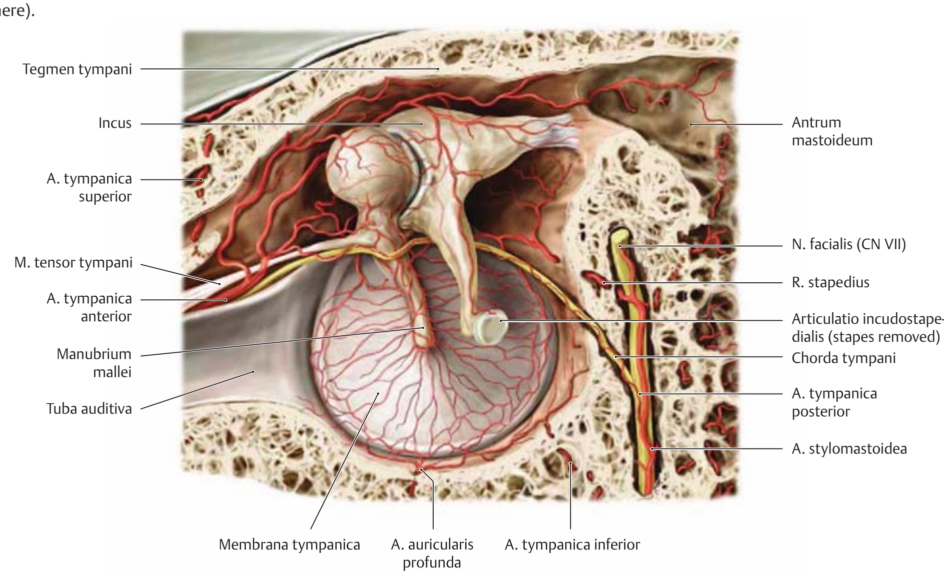
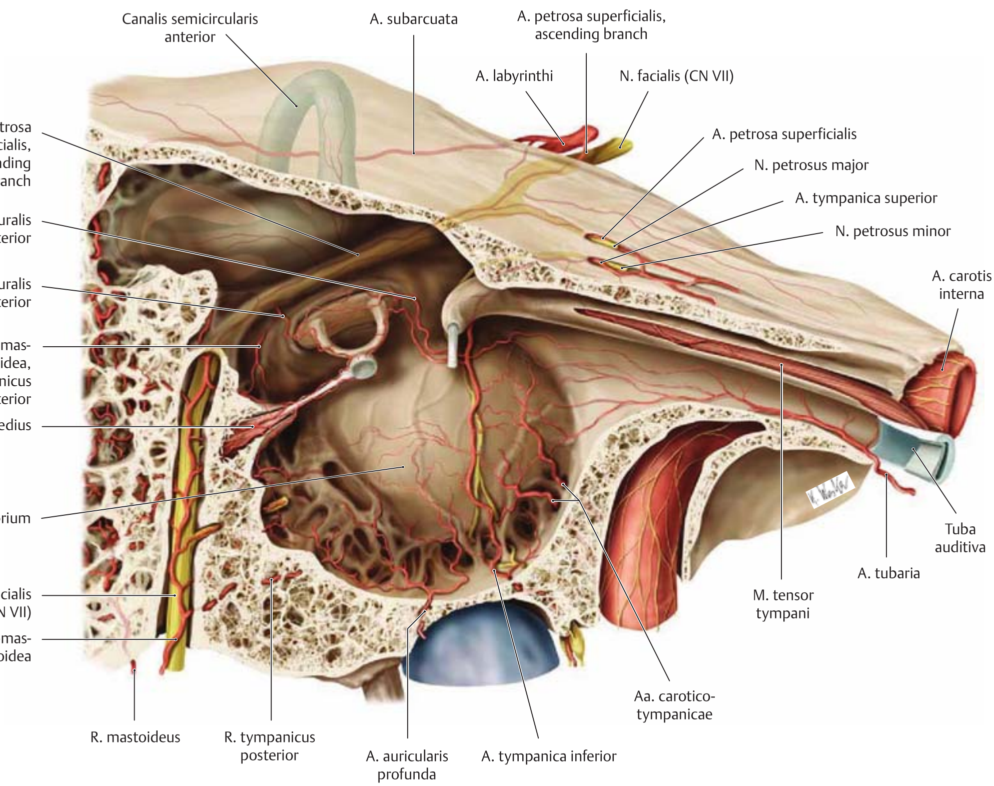


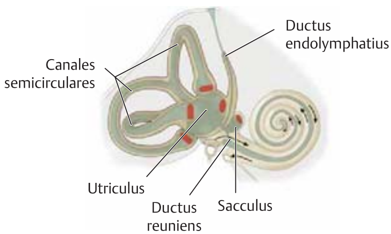
Fig. 35.18 **Arteries of the middle ear: Tympanic cavity**
Right petrous bone, anterior view. *Removed:* Malleus, incus, portions of chorda tympani, and a. tympanica anterior.



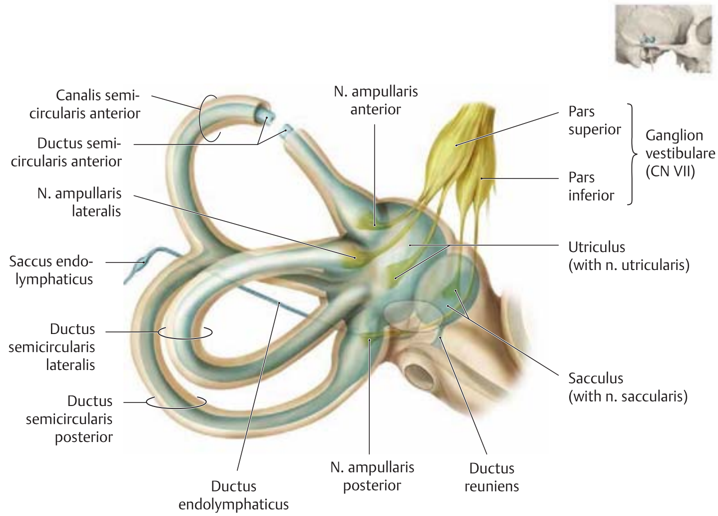
Inner Ear (Auris Interna)

The inner ear consists of the vestibular apparatus (for balance) and the auditory apparatus (for hearing). Both are formed by a membranous labyrinth filled with endolympha floating within a bony labyrinth filled with perilympha and embedded in pars petrosa of os temporale.

Fig. 35.19 **Vestibular apparatus**
Right lateral view.

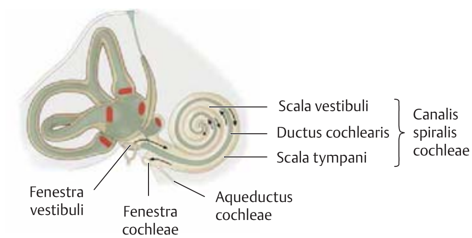


A Schematic. Cristae ampullares and maculae of utriculus and sacculus shown in red.

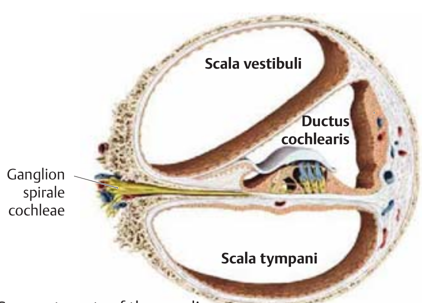


B Structure of the vestibular apparatus.

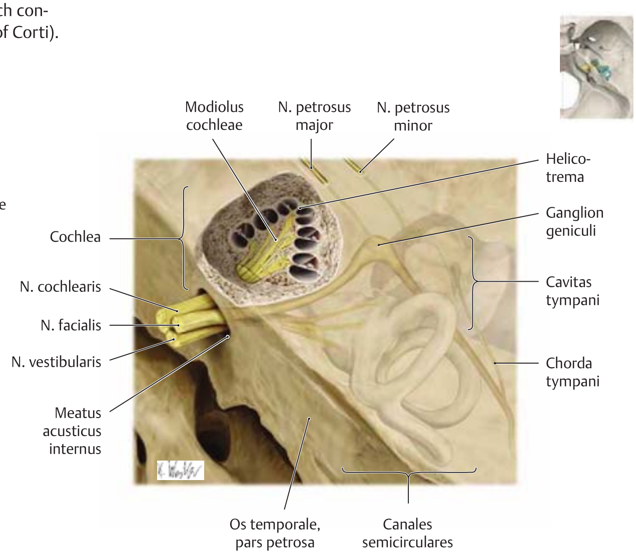
Fig. 35.20 **Auditory apparatus**
The cochlear labyrinth and its bony shell form the cochlea, which contains the sensory epithelium of the auditory apparatus (organ of Corti).



A Schematic.



B Compartments of the canalis spiralis cochleae, cross section.



C Location of the cochlea. Superior view of pars petrosa with the cochlea sectioned transversely. The bony canal of the cochlea (canalis spiralis cochlea) makes 2.5 turns around its bony axis (modiolus cochleae).

Fig. 35.21 Innervation of the membranous labyrinth
Right ear, anterior view. N. vestibulocochlearis (CN VIII; see p. 480) transmits afferent impulses from the inner ear to the brainstem through the meatus acousticus internus. N. vestibulocochlearis is divided into the n. vestibularis and n. cochlearis. *Note:* The sensory organs in the semicircular canals respond to angular acceleration, and the macular organs (sacculus and utriculus) respond to horizontal and vertical linear acceleration.

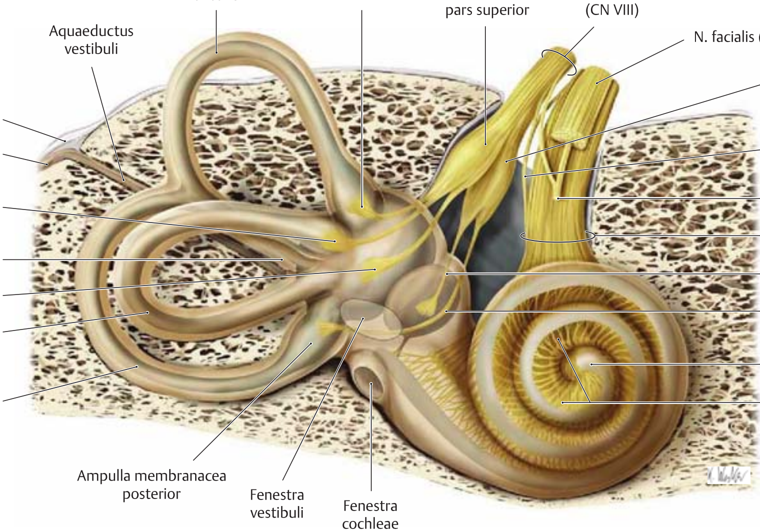
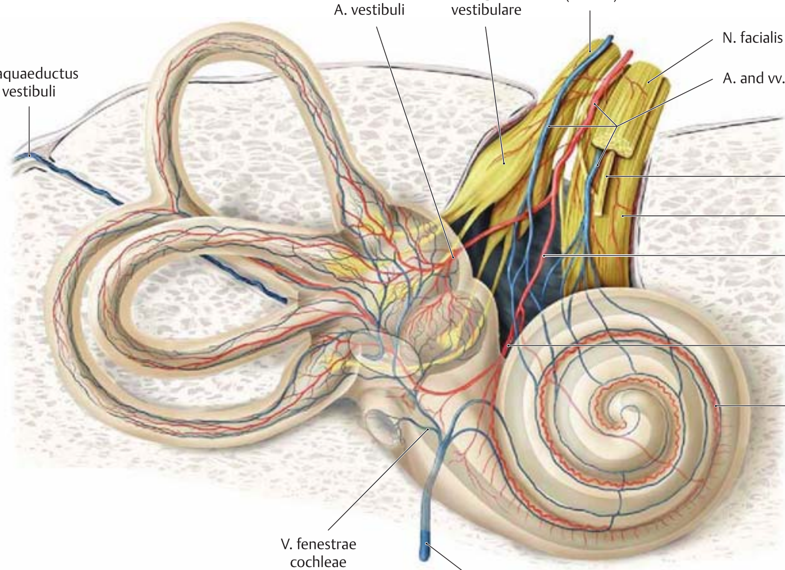


Fig. 35.22 Blood vessels of the inner ear
Right anterior view. The labyrinth receives its blood supply from the a. labyrinthi, a branch of the a. inferior anterior cerebelli (see p. 608).



Bones of the Oral Cavity (Cavitas Oris)

The floor of the nasal cavity (the maxilla and palatine bone) forms the roof of the oral cavity, the palatum durum. The two horizontal processes of the maxilla (processus palatinus) grow together during development, eventually fusing at the sutura palatina mediana. Failure to fuse results in a cleft palate.

Fig. 36.1 Palatum durum: Inferior view

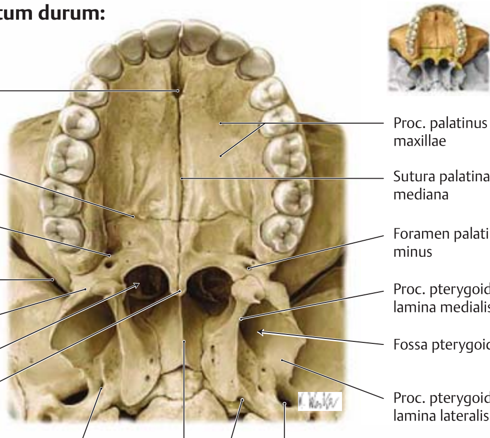


Fig. 36.2 Palatum durum: Superior view
Removed: Maxilla (upper part).

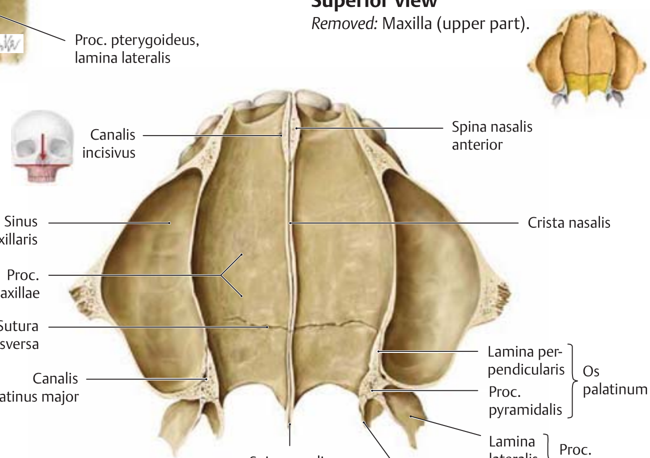


Fig. 36.3 Palatum durum: Oblique posterior view

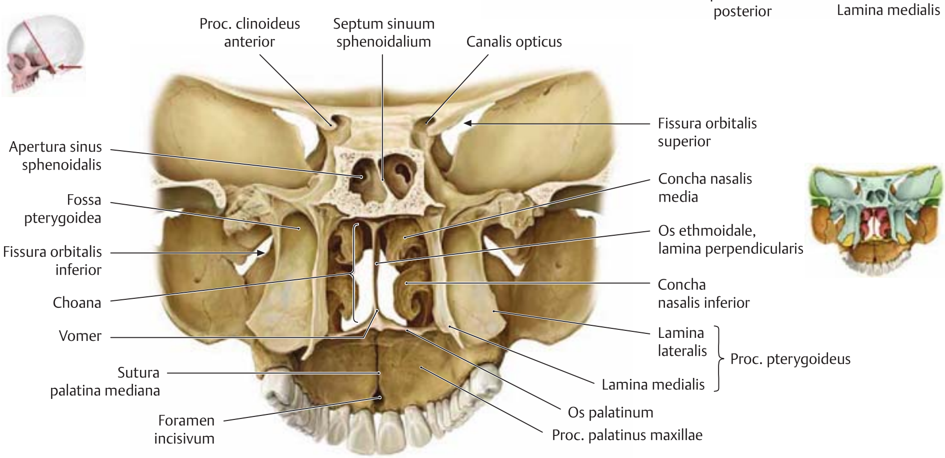
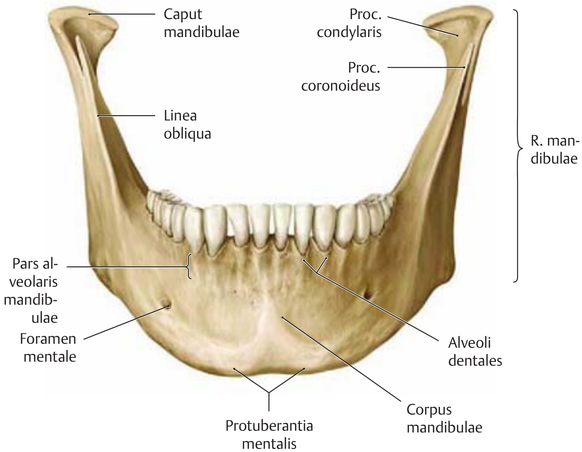
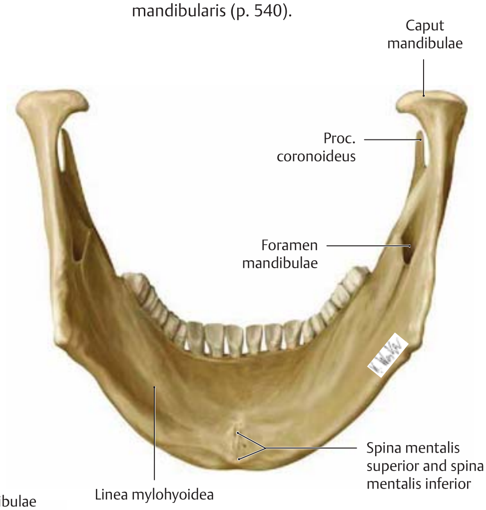


Fig. 36.4 Mandibula

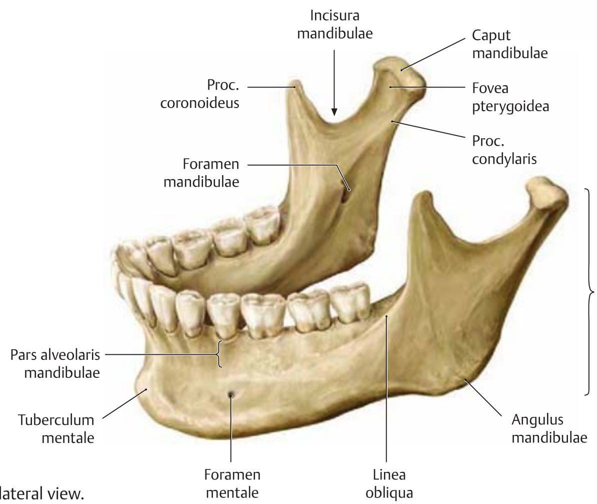
The mandibula (jaw) is connected to the viscerocranium at the articulatio temporomandibularis (p. 540).



A Anterior view.



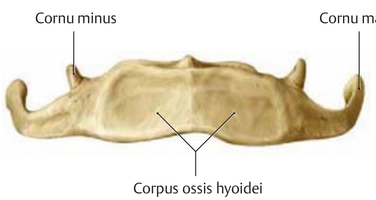
B Posterior view.



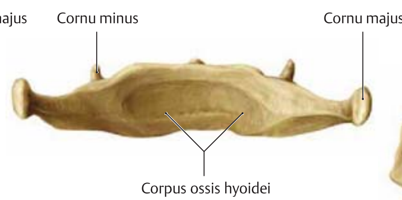
C Oblique left lateral view.

Fig. 36.5 Os hyoideum

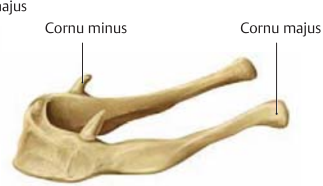
The os hyoideum is suspended in the neck by muscles between the floor of the mouth and the larynx. Although not listed among the cranial bones, os hyoideum gives attachment to the muscles of the oral floor. The cornu majus and corpus of os hyoideum are palpable in the neck.



A Anterior view.



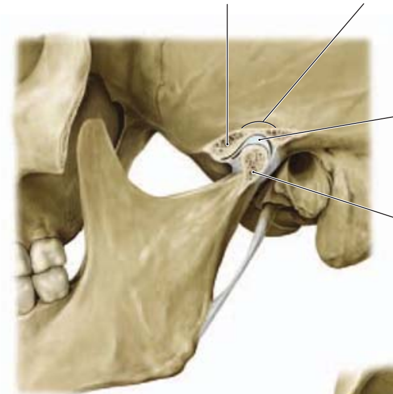
B Posterior view.



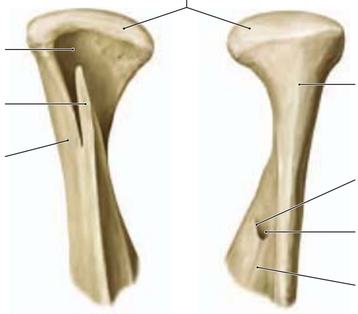
C Oblique left lateral view.

Articulatio Temporomandibularis

Fig. 36.6 **Articulatio temporomandibularis**
The caput mandibulae articulates with the fossa mandibularis in the articulatio temporomandibularis.

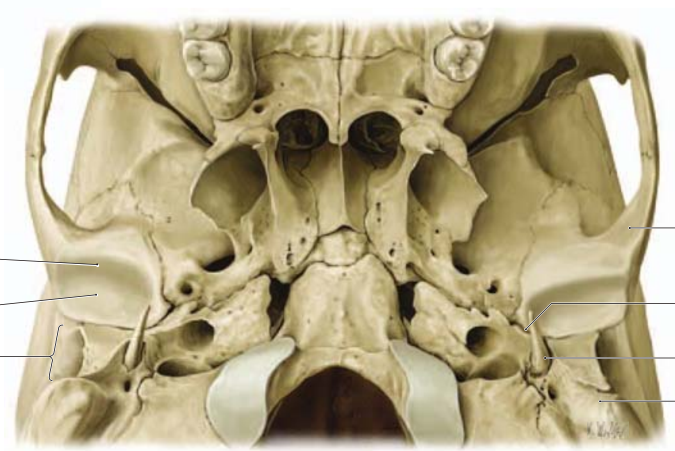


A Sagittally sectioned articulatio temporomandibularis, left lateral view.



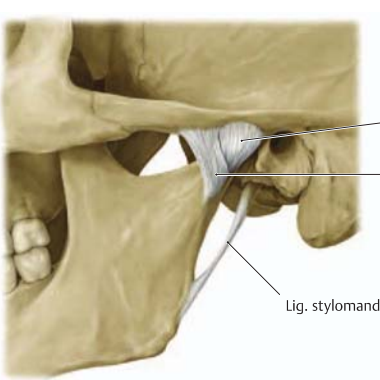
B Caput mandibulae, anterior view.

C Caput mandibulae, posterior view.

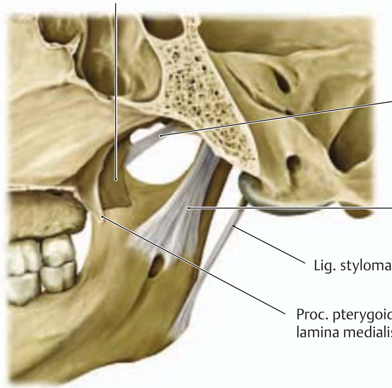


D Fossa mandibularis of the articulatio temporomandibu-laris, inferior view.

Fig. 36.7 **Ligaments of articulatio temporomandibularis**



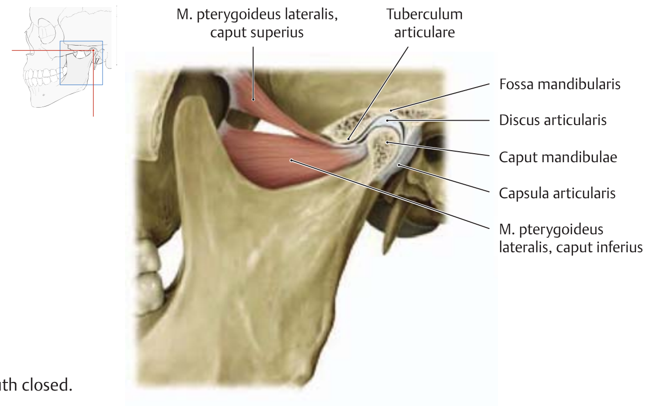
A Lateral view of the left articulatio temporomandibularis.



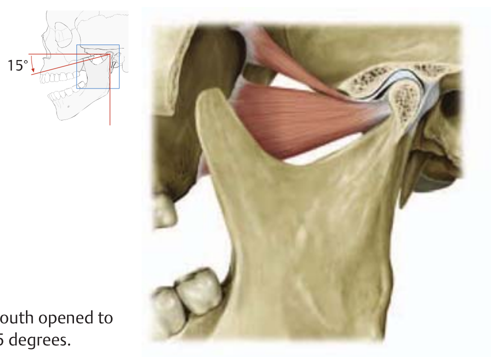
B Medial view of the right articulatio temporomandibularis.

Fig. 36.8 Movement of articulatio temporomandibularis

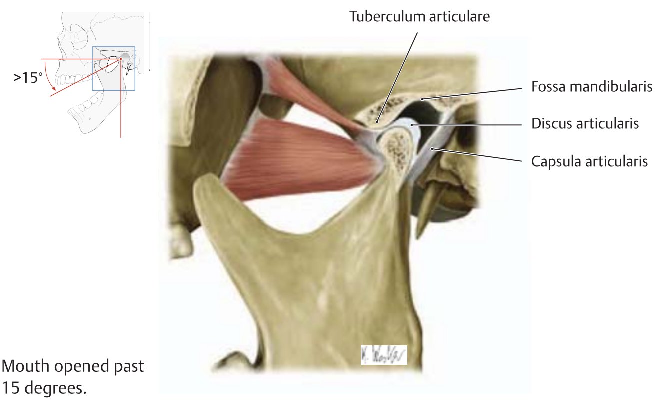
Left lateral view. Up to 15 degrees of abduction, caput mandibulae remains in the fossa mandibularis. Past 15 degrees, caput mandibulae glides forward onto the tuberculum articulare.



A Mouth closed.



B Mouth opened to 15 degrees.



C Mouth opened past 15 degrees.

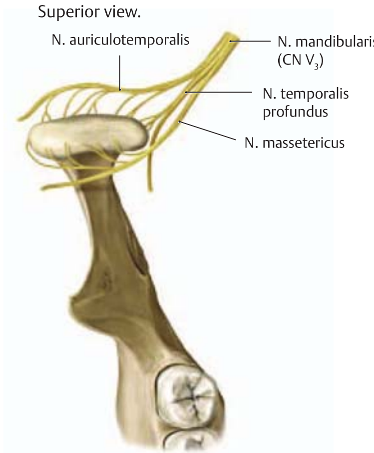
Clinical

Dislocation of articulatio temporomandibularis

Dislocation may occur if caput mandibulae slides past the tuberculum articulare. The mandibula then becomes locked in a protruded position, a condition reduced by pressing on the mandibular row of teeth.

Fig. 36.9 Innervation of the joint capsule of articulatio temporomandibularis

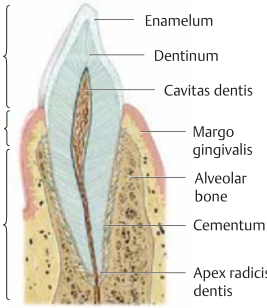
Superior view.



Teeth (Dentes)

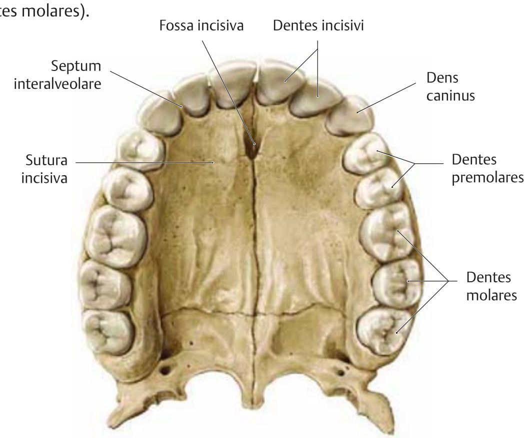
Fig. 36.10 **Structure of a tooth**
Each tooth consists of hard tissue (enamel, dentin, cementum) and soft tissue (dental pulp) arranged into a crown, neck (cervix), and root.

A Principal parts of a tooth (molar).

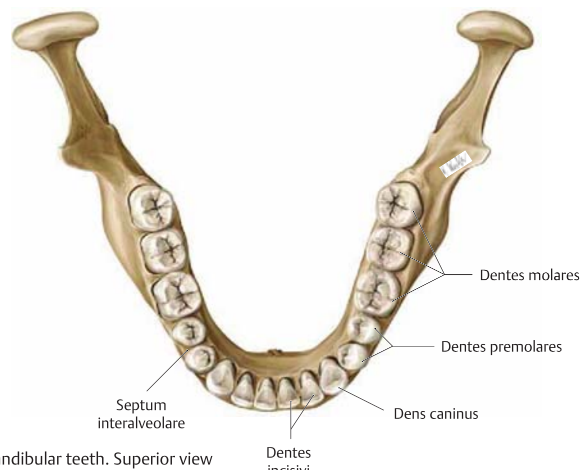


B Histology of a tooth (mandibular dens incisivus).

Fig. 36.11 **Permanent teeth**
Each half of the maxilla and mandibula contains a set of three anterior teeth (two dentes incisivi, one dens caninus) and five posterior (postcanine) teeth (two dentes premolares, three dentes molares).



A Maxillary teeth. Inferior view of maxilla.



B Mandibular teeth. Superior view of mandibula.

Fig. 36.12 **Tooth surfaces**
The top of the tooth is known as the occlusal surface.

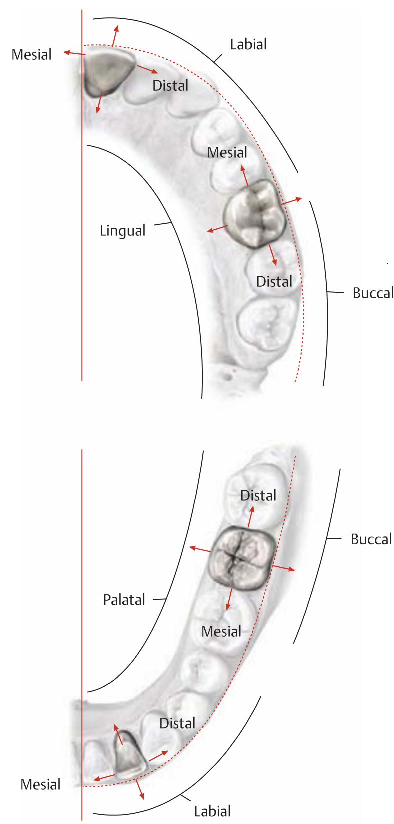


Fig. 36.13 Coding of the teeth

In the United States, the 32 permanent teeth are numbered sequentially (not assigned to quadrants). *Note:* The 20 deciduous (baby) teeth are coded A to J (upper arch), and K to T in a similar clockwise fashion. The third upper right molar is 1; the second upper right premolar is A.

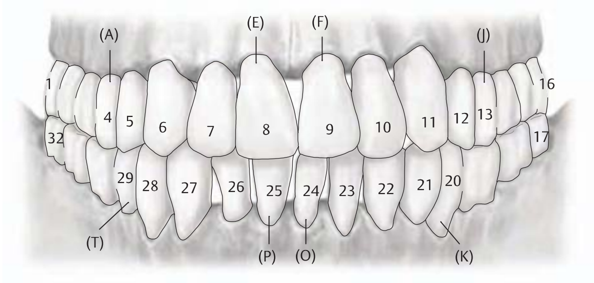
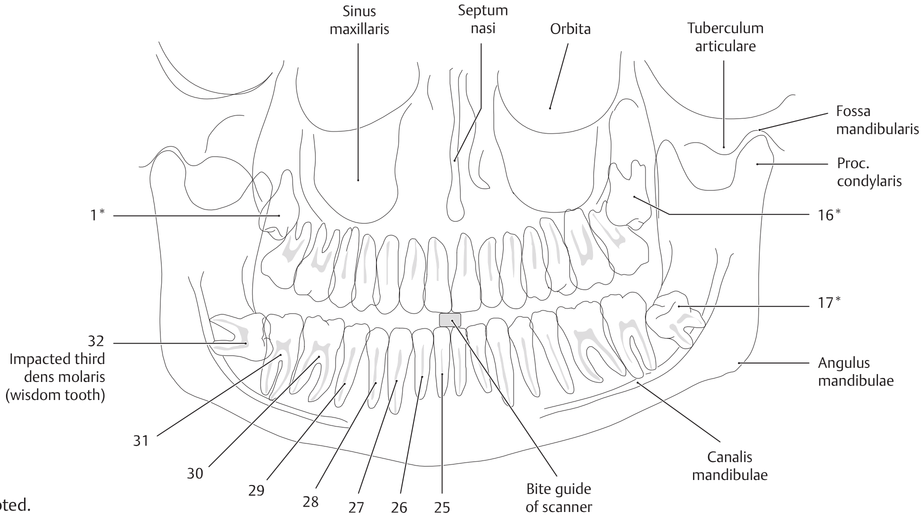


Fig. 36.14 Dental panoramic tomogram

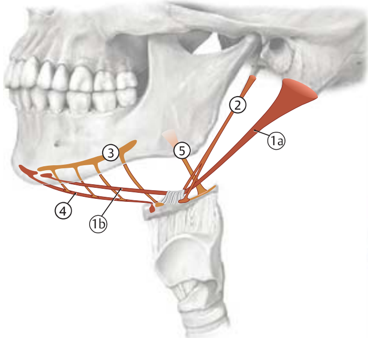
The dental panoramic tomogram (DPT) is a survey radiograph that allows preliminary assessment of the temporomandibular joints, maxillary sinuses, maxillomandibular bone, and dental status (carious lesions, location of wisdom teeth, etc.). *DPT courtesy of Dr. U. J. Rother, Director of the Department of Diagnostic Radiology, Center for Dentistry and Oromaxillofacial Surgery, Eppendorf University Medical Center, Hamburg, Germany.*



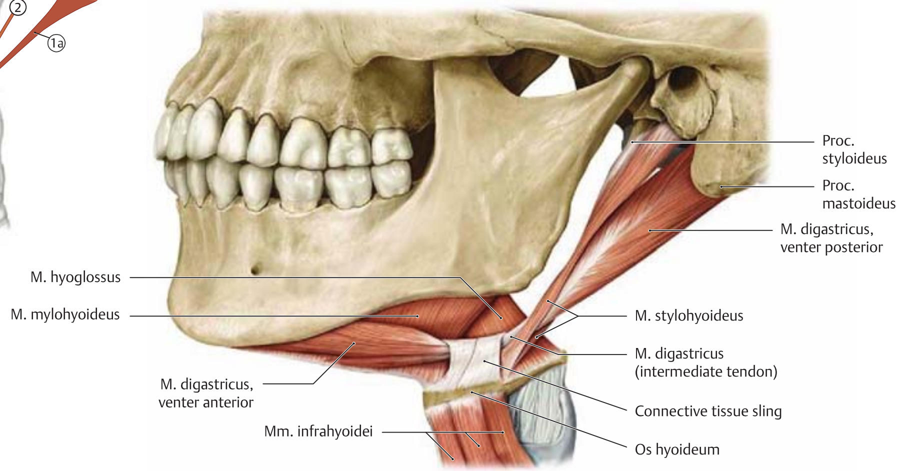
*Not fully erupted.

Muscles of the Oral Cavity

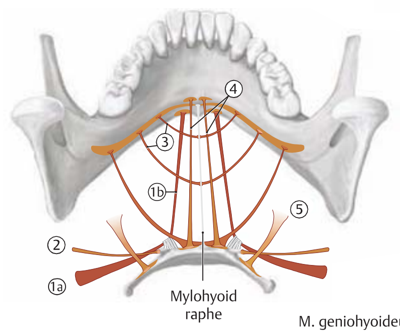
Fig. 36.15 **Muscles of the oral floor**
See pp. 562–563 for the infrahyoid muscles.



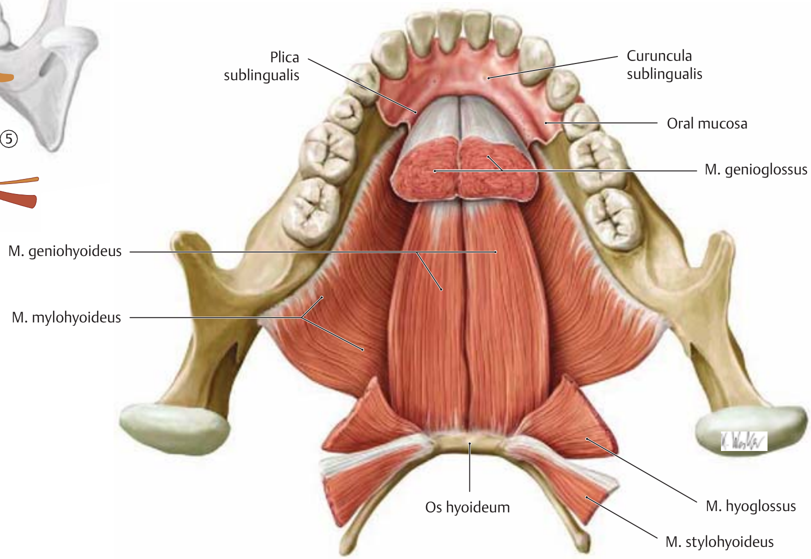
A Suprahyoid muscles, left lateral view.



B Left lateral view.



C Suprahyoid muscles, superior view.



D Superior view of mandibula and os hyoideum.

Table 36.1 Suprahyoid muscles

Muscle		Origin	Insertion		Innervation	Action
① M. diagastricus	①a Venter anterior	Mandibula (fossa digastrica)	Os hyoideum (corpus)	Via an intermediate tendon with a fibrous loop	N. mylohyoideus (from CN V_3)	Elevates hyoid bone (during swallowing), assists in opening mandibula
	①b Venter posterior	Os temporale (incisura mastoidea, medial to proc. mastoideus)			N. facialis (CN VII)	
② M. stylohyoideus		Os temporale (proc. styloideus)		Via a split tendon		
③ M. mylohyoideus		Mandibula (linea mylohyoidea)		Via median tendon of insertion (raphe mylohyoidea)	N. mylohyoideus (from CN V_3)	Tightens and elevates oral floor, draws hyoid bone forward (during swallowing), assists in opening mandible and moving it side to side (mastication)
④ M. geniohyoideus		Mandibula (spina mentalis inferior)		Os hyoideum (corpus)	R. ventralis of C1 via n. hypoglossus (CN XII)	Draws hyoid bone forward (during swallowing), assists in opening mandible
⑤ M. hyoglossus		Os hyoideum (superior border of cornu majus)	Sides of tongue		N. hypoglossus (CN XII)	Depresses the tongue

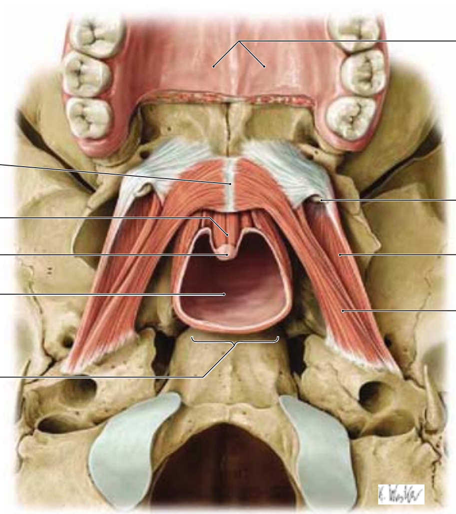


Fig. 36.16 **Muscles of palatum molle**
Inferior view. The palatum molle forms the posterior boundary of the oral cavity, separating it from the oropharynx.

Table 36.2 Muscles of the Palatum molle

Muscle	Origin	Insertion	Innervation	Action
M. tensor veli palatini	Lamina medialis of proc. pterygoideus (fossa scaphoidea); spina ossis sphenoidalis; cartilage of tuba auditiva	Aponeurosis palatina	N. pterygoideus medialis (CN V_3 via ganglion oticum)	Tightens soft palate; opens inlet to pharyngotympanic tube (during swallowing, yawning)
M. levator veli palatini	Cartilage of tuba auditiva; os temporale (pars petrosa)		N. accessorius (CN XI, pars cranialis) via plexus pharyngeus (n. vagus, CN X)	Raises soft palate to horizontal position
M. uvulae	Uvula (mucosa)	Aponeurosis palatina; spina nasalis posterior		Shortens and raises uvula
M. palatoglossus*	Tongue (side)	Aponeurosis palatina		Elevates tongue (posterior portion); pulls soft palate onto tongue
M. palatopharyngeus*				Tightens soft palate; during swallowing pulls pharyngeal walls superiorly, anteriorly, and medially

*See pp. 548, 555.

Innervation of the Oral Cavity

Fig. 36.17 **N. trigeminus in the oral cavity**
Right lateral view.

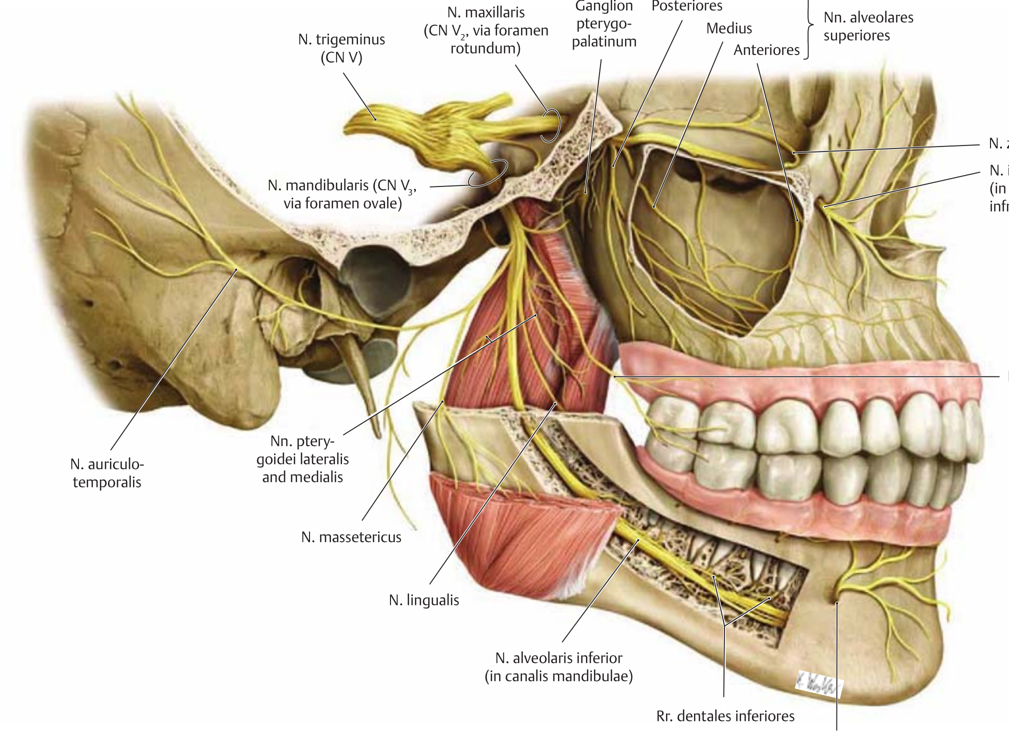
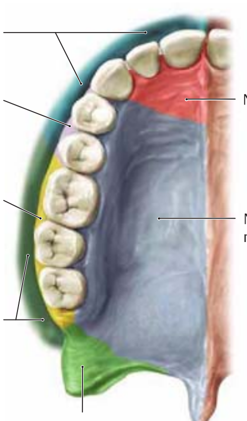
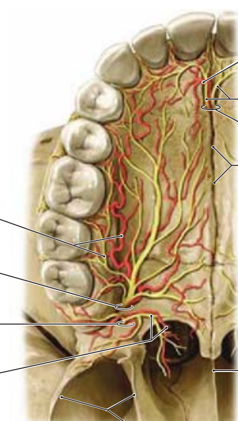


Fig. 36.18 **Neurovasculature of palatum durum**
Inferior view. The palatum durum receives sensory innervation primarily from terminal branches of n. maxillaris (CN V2). The arteries of the hard palate arise from a. maxillaris.



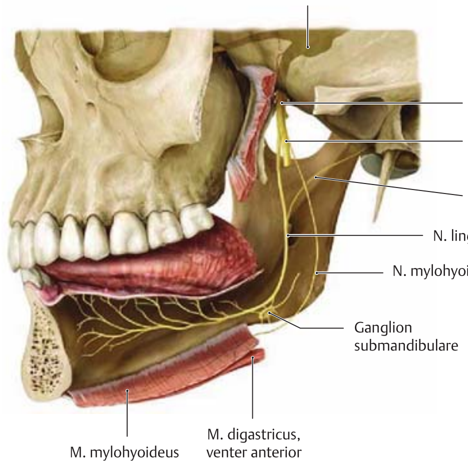
A Sensory innervation. *Note:* N. buccalis is a branch of n. mandibularis (CN V_3).



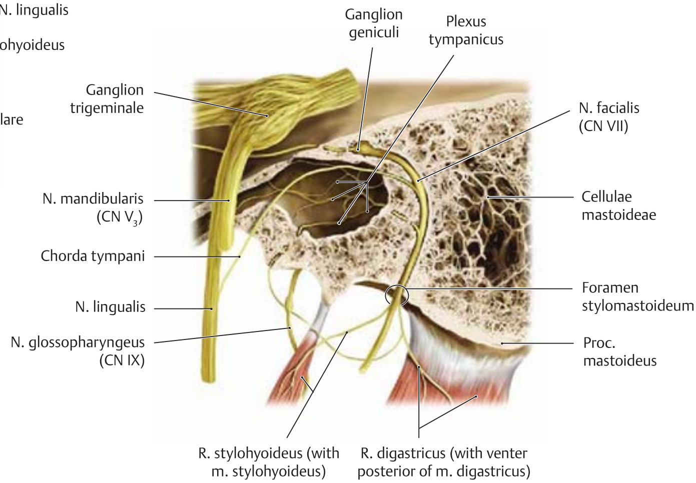
B Nerves and arteries.

The muscles of the oral floor have a complex nerve supply with contributions from n. mandibularis (CN V3), n. facialis (CN VII), and C1 spinal nerve via n. hypoglossus (CN XII).

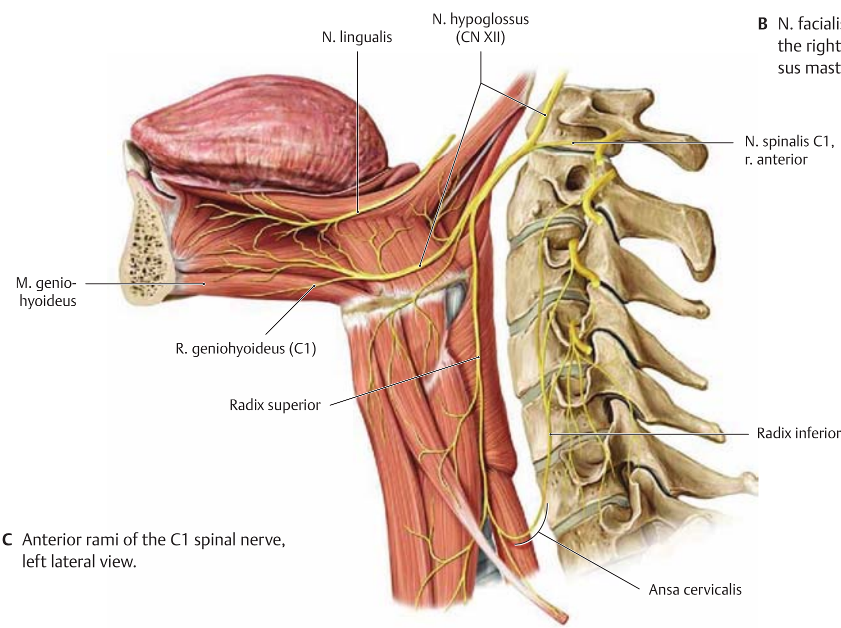
Fig. 36.19 Innervation of the oral floor muscles



A N. mylohyoideus (CN V_3). Left lateral view with the left half of mandibula removed.



B N. facialis (CN VII). Sagittal section through the right pars petrosa at the level of processus mastoideus, medial view.

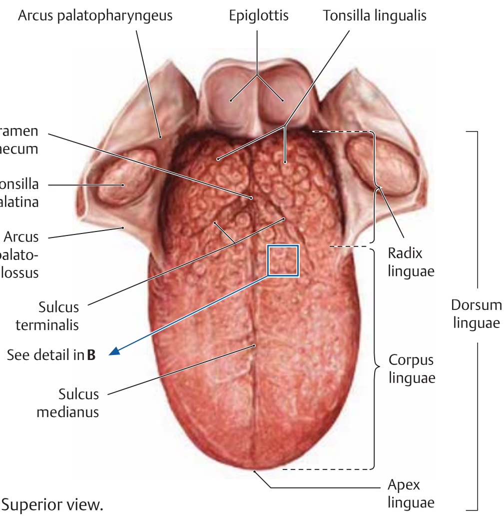


C Anterior rami of the C1 spinal nerve, left lateral view.

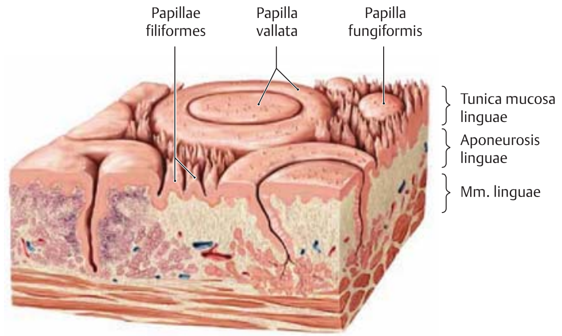
Tongue (Lingua)

The dorsum of the tongue is covered by a highly specialized mucosa that supports its sensory functions (taste and fine tactile discrimination; see p. 616). The tongue is endowed with a very powerful muscular body to support its motor properties during mastication, swallowing, and speaking.

Fig. 36.20 **Structure of the tongue**
The V-shaped sulcus terminalis divides the tongue into an anterior (oral, pars presulcalis) and a posterior (pharyngeal, pars postsulcalis) part.

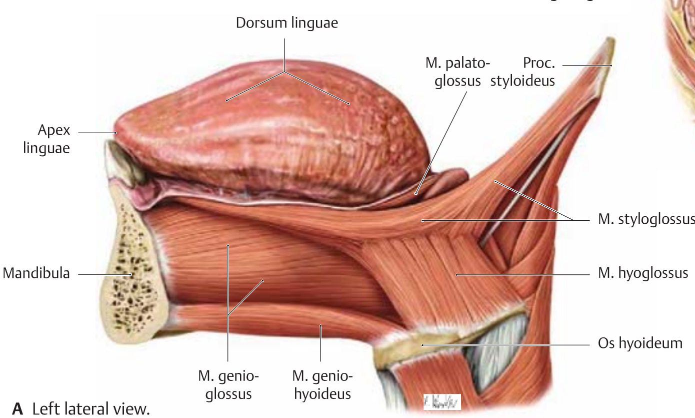


A Superior view.

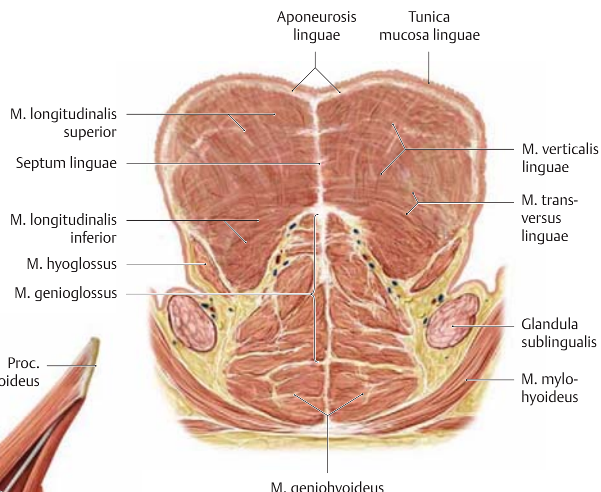


B Papillae linguales, sectional block diagram. The connective tissue between the mucosal surface and musculature contains many small seromucous glands (not shown).

Fig. 36.21 **Muscles of the tongue**
The extrinsic lingual muscles (m. genioglossus, m. hyoglossus, m. palatoglossus, and m. styloglossus) have bony attachments and move the tongue as a whole. The intrinsic lingual muscles (mm. longitudinales superior and inferior, m. transversus linguae, and m. verticalis linguae) have no bony attachments and alter the shape of the tongue.



A Left lateral view.



B Coronal section, anterior view.

Fig. 36.22 **Somatosensory and taste innervation of the tongue**
Anterior view.

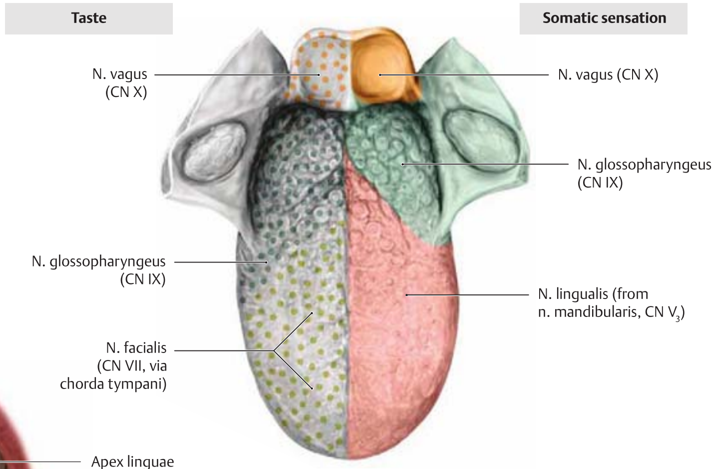
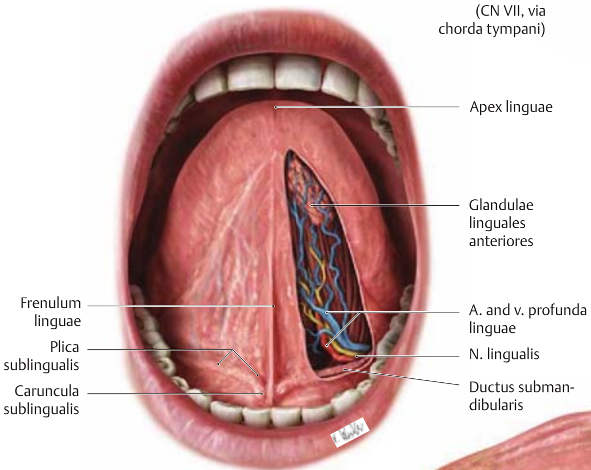
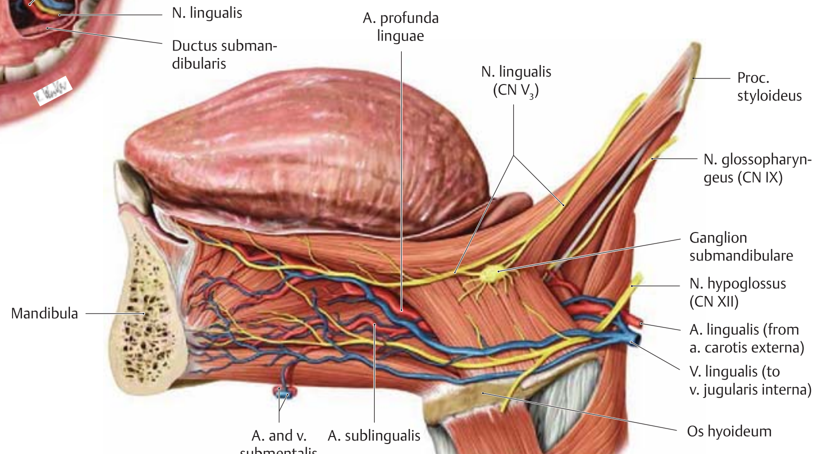


Fig. 36.23 **Neurovasculature of the tongue**
The lingual muscles receive somatomotor innervation from n. hypoglossus (CN XII), with the exception of m. palatoglossus (supplied by n. vagus, CN X).



A Inferior surface of the tongue.

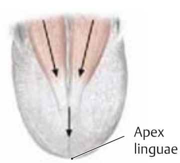


B Left lateral view.

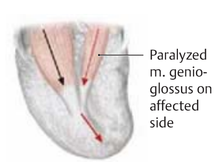
Clinical

Unilateral n. hypoglossus palsy
Damage to n. hypoglossus causes paralysis of m. genioglossus on the affected side. The healthy (innervated) m. genioglossus on the unaffected side will therefore dominate. Upon protrusion, the tongue will deviate *toward* the paralyzed side.

A Active protrusion with an intact n. hypoglossus.

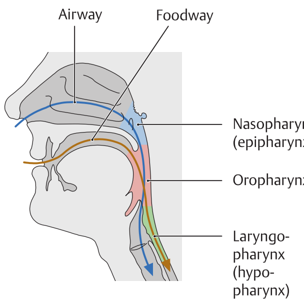


B Active protrusion with a unilateral lesion of n. hypoglossus.



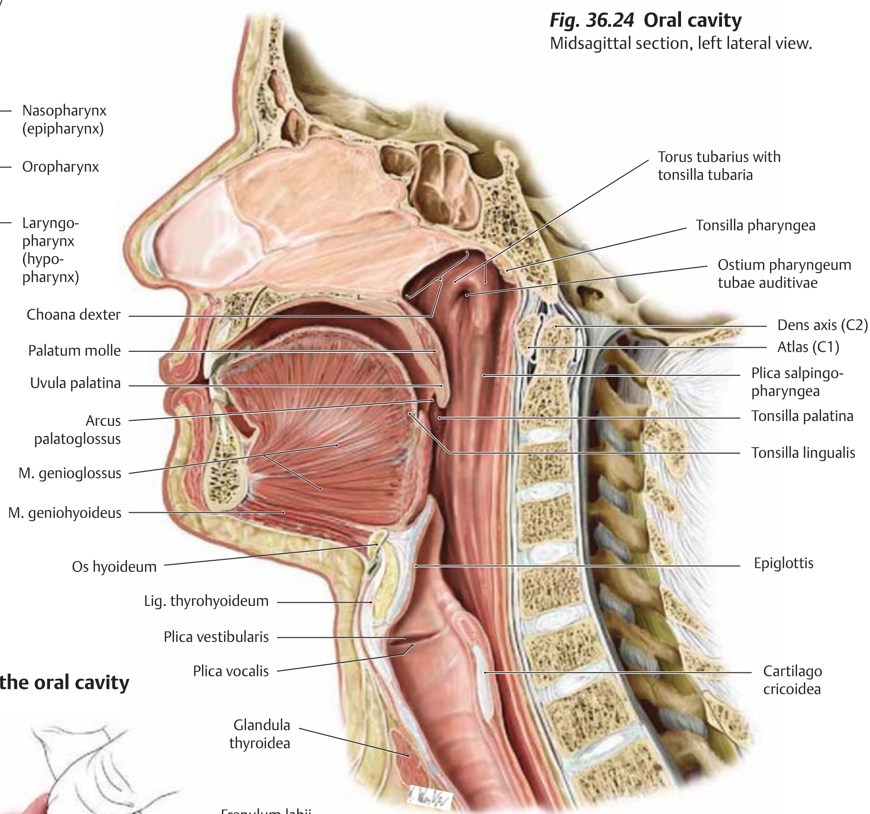
Topography of the Oral Cavity & Salivary Glands

The oral cavity is located below the nasal cavity and anterior to the pharynx. It is bounded by the hard and soft palates, the tongue and muscles of the oral floor, and the uvula.



A Organization of the oral cavity.

Fig. 36.24 **Oral cavity**
Midsagittal section, left lateral view.



B Boundaries of the oral cavity.

Fig. 36.25 **Divisions of the oral cavity**
Anterior view.

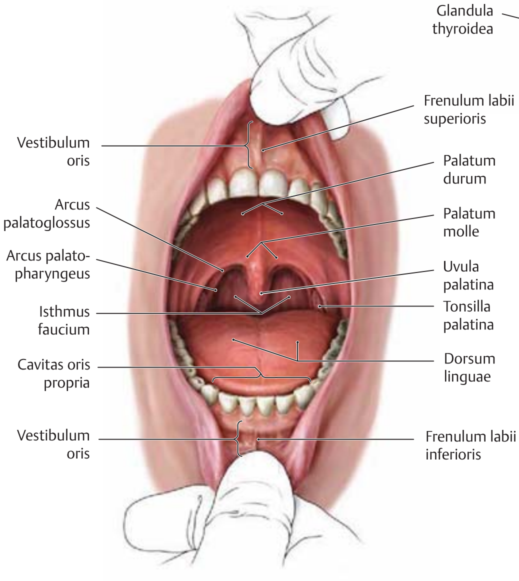
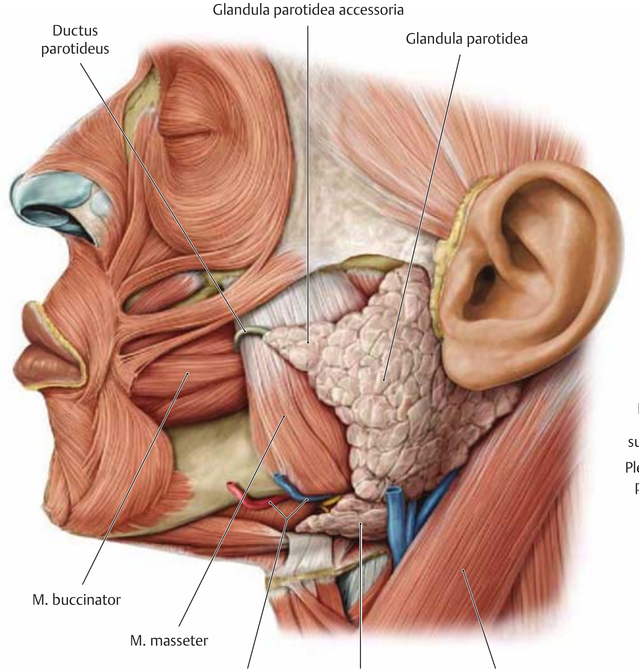


Table 36.3 **Divisions of the oral cavity**

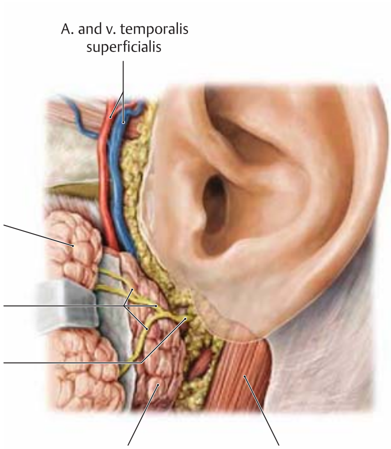
Part	Anterior boundary	Posterior boundary
Vestibulum oris	Labia/cheek	Arcus dentalis
Cavitas oris propria	Arcus dentalis	Arcus palatoglossus
Fauces (throat)	Arcus palatoglossus	Arcus palatopharyngeus

The three large, paired salivary glands are the glandulae parotidea, submandibularis, and sublingualis. The glandula parotidea is a purely serous (watery) salivary gland. The glandula sublingualis is predominantly mucous; the glandula submandibularis is a mixed seromucous gland.

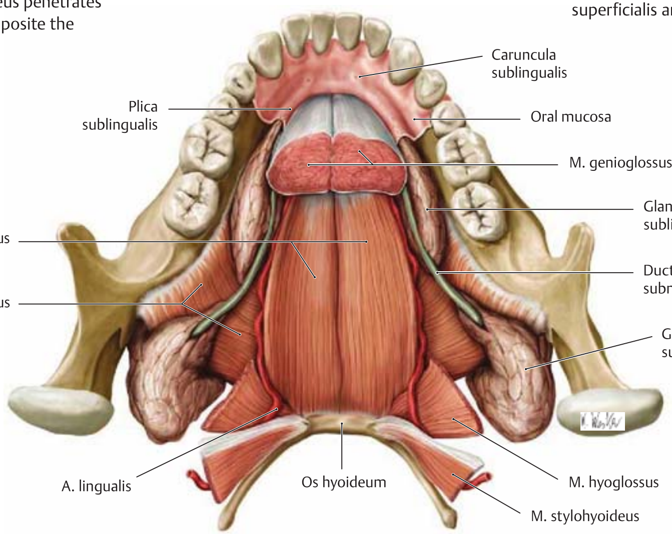
Fig. 36.26 Salivary glands



A Glandula parotidea, left lateral view. *Note:* The ductus parotideus penetrates m. buccinator to open opposite the second upper molar.



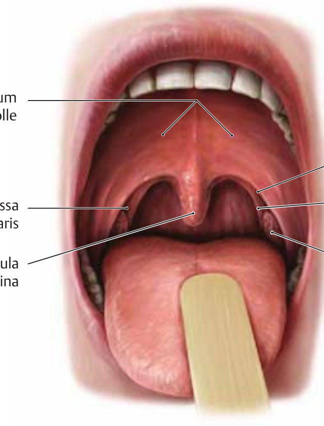
B N. facialis in glandula parotidea, left lateral view. The ramification of n. facialis into the plexus intraparotideus (see p. 478) separates glandula parotidea into a pars superficialis and a pars profunda.



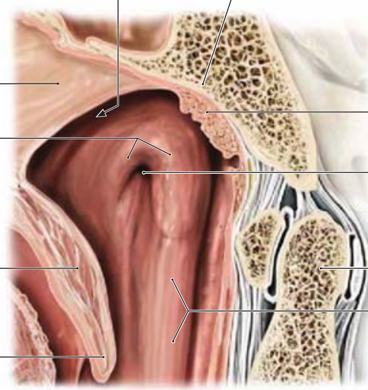
C Glandulae submandibularis and sublingualis, superior view with tongue removed.

Tonsils & Pharynx

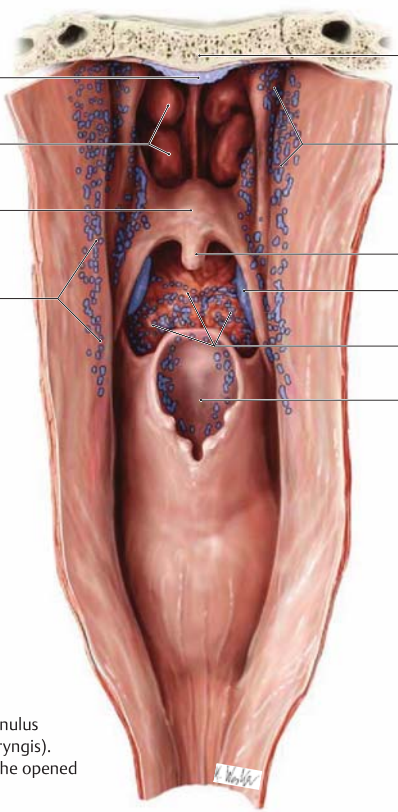
Fig. 36.27 **Tonsils**



A Tonsilla palatina, anterior view.



B Tonsilla pharyngea. Sagittal section through the roof of the pharynx.



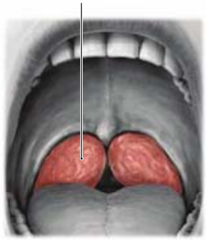
C Waldeyer's ring (anulus Lymphoideus pharyngis). Posterior view of the opened pharynx.

Table 36.4 **Structures in Waldeyer's ring**

Tonsil	#
Tonsilla pharyngea	1
Tonsillae tubariae	2
Tonsillae palatinae	2
Tonsilla lingualis	1
Lateral bands	2

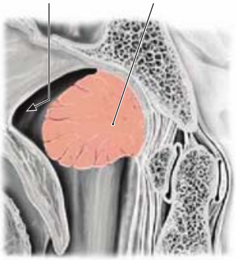
Clinical

Tonsil infections
Abnormal enlargement of the tonsillae palatinae due to severe viral or bacterial infection can result in obstruction of the oropharynx, causing difficulty swallowing.



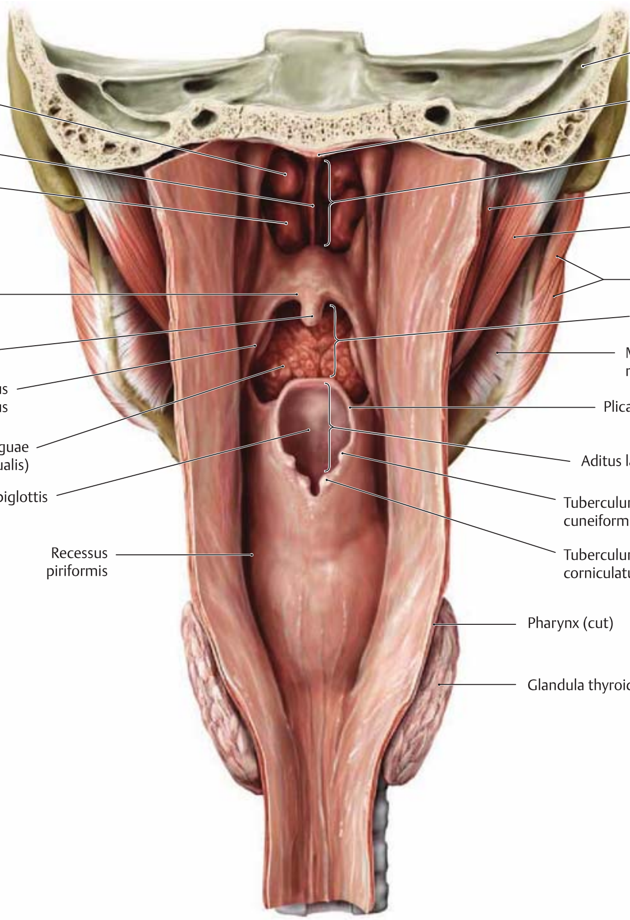
A

Particularly well developed in young children, tonsilla pharyngea begins to regress at 6 to 7 years of age. Abnormal enlargement is common, with the tonsil bulging into the nasopharynx and obstructing air passages, forcing the child to "mouth breathe."



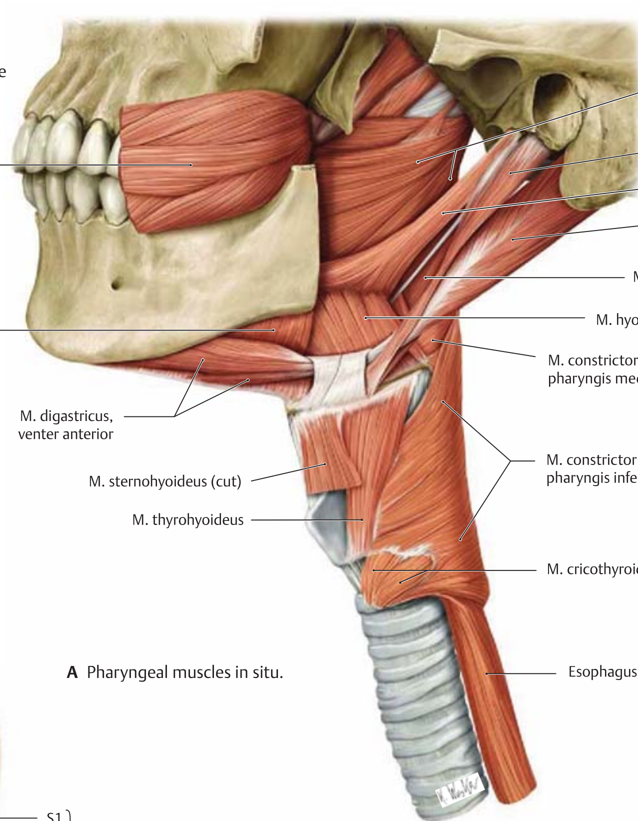
B

Fig. 36.28 **Pharyngeal mucosa**
Posterior view of the opened pharynx. The anterior portion of the muscular tube contains three openings: choanae (to the nasal cavity), isthmus faucium (to the oral cavity), and aditus Laryngis (to the laryngeal inlet).

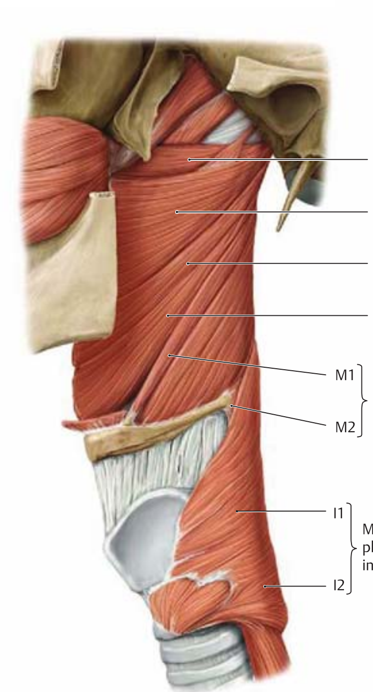


Pharyngeal Muscles

Fig. 36.29 **Pharyngeal muscles: Left lateral view**
The pharyngeal musculature consists of the pharyngeal constrictors and the relatively weak pharyngeal elevators.



A Pharyngeal muscles in situ.

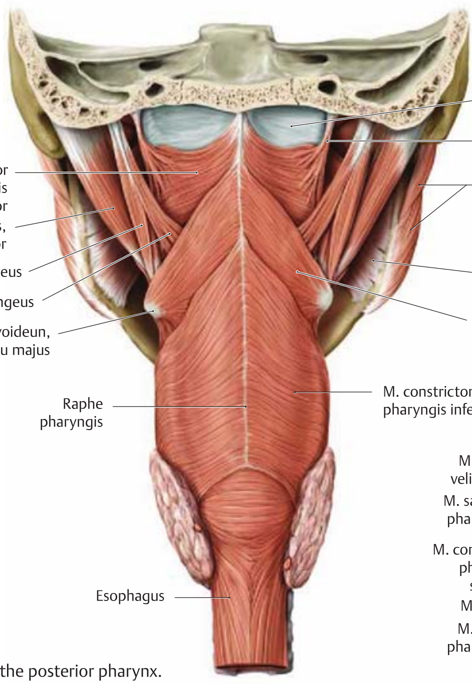


B Subdivisions of the pharyngeal constrictors.

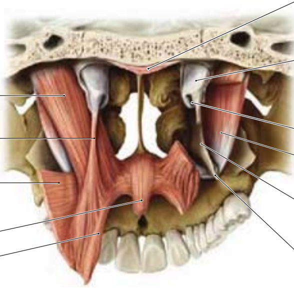
Table 36.5 **Pharyngeal constrictors**

M. constrictor pharyngis superior	
S1	Pars pterygopharyngea
S2	Pars buccopharyngea
S3	Pars mylopharyngea
S4	Pars glossopharyngea
M. constrictor pharyngis medius	
M1	Pars chondropharyngea
M2	Pars ceratopharyngea
M. constrictor pharyngis inferior	
I1	Pars thyropharyngea
I2	Pars cricopharyngea

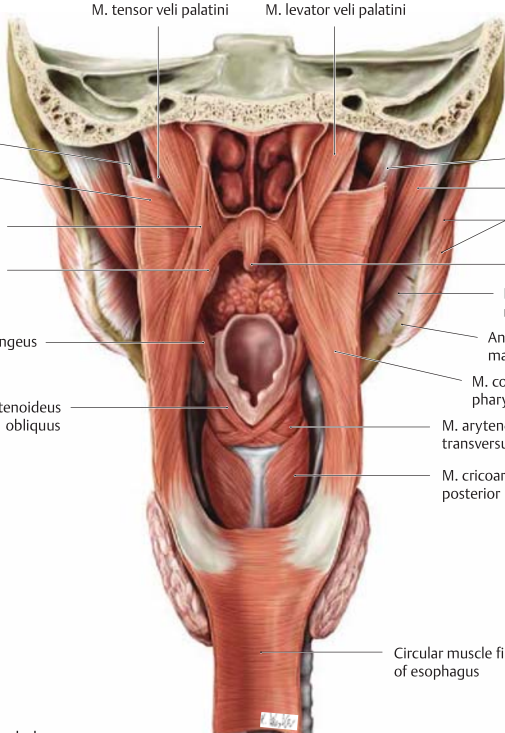
Fig. 36.30 **Pharyngeal muscles: Posterior view**



A Muscles of the posterior pharynx.



B Muscles of palatum molle and tuba auditiva. The muscles of the fauces form the posterior boundary of the oral cavity.



C Muscles in the opened pharynx.

Neurovasculature of the Pharynx

Fig. 36.31 Neurovasculature in the parapharyngeal space
Posterior view. *Removed:* Columna vertebralis and posterior structures.

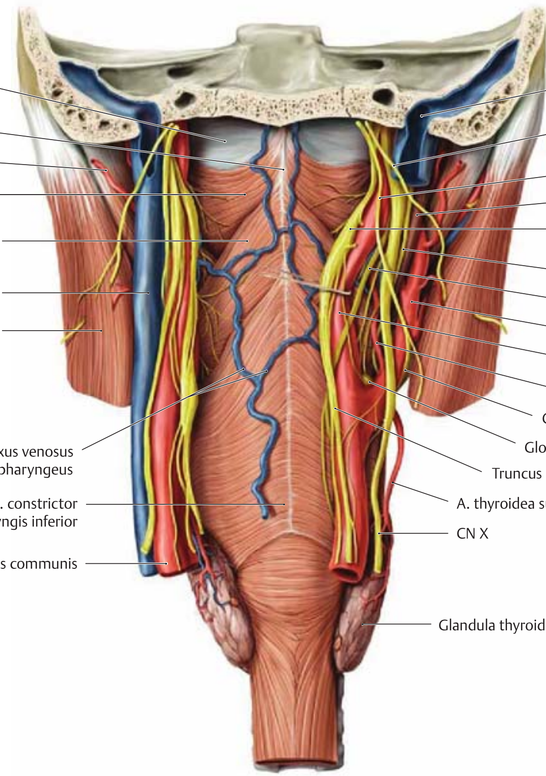
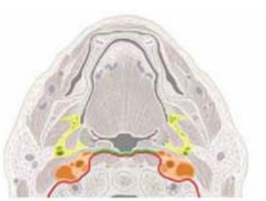
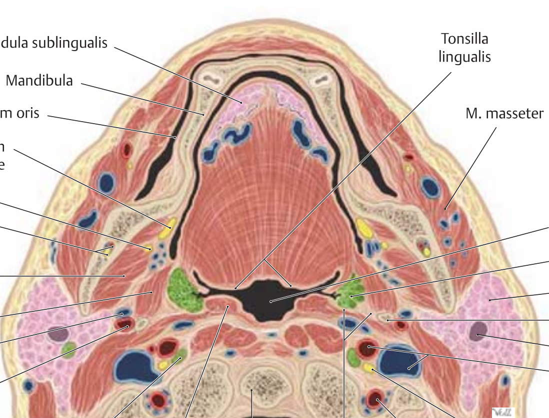


Fig. 36.32 Parapharyngeal space
Transverse section, superior view.

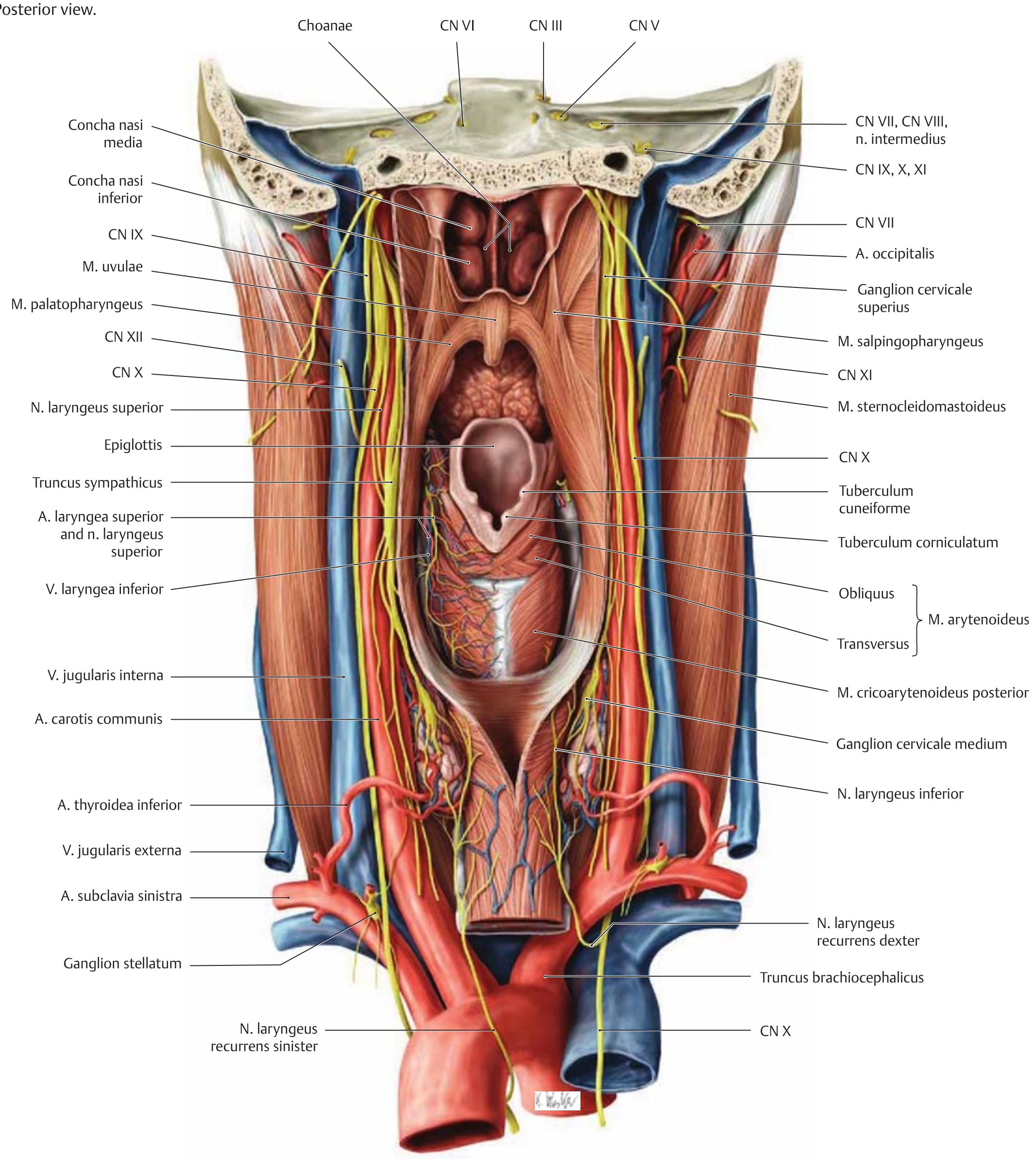


A Parapharyngeal space. The parapharyngeal space consists of a retropharyngeal (green) and a lateropharyngeal space. The lateropharyngeal space is further subdivided into an anterior (yellow) and a posterior (orange) part. Note the deep layer of fascia cervicalis (prevertebral lamina, red).



B Superior view of the transverse section at the level of fossa tonsillaris.

Fig. 36.33 **Neurovasculature of the opened pharynx**
Posterior view.



CN III = N. oculomotorius, CN V = N. trigeminus, CN VI = N. abducens,
CN VII = N. facialis, CN VIII = N. vestibulocochlearis, CN IX = N. glossopharyngeus,
CN X = N. vagus, CN XI = N. accessorius, CN XII = N. hypoglossus
See Chapter 31 for the cranial nerves.

Bones & Ligaments of the Neck

Fig. 37.1 **Boundaries of the neck**
Left lateral view.

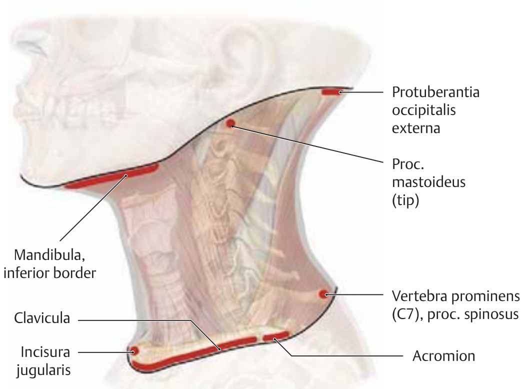
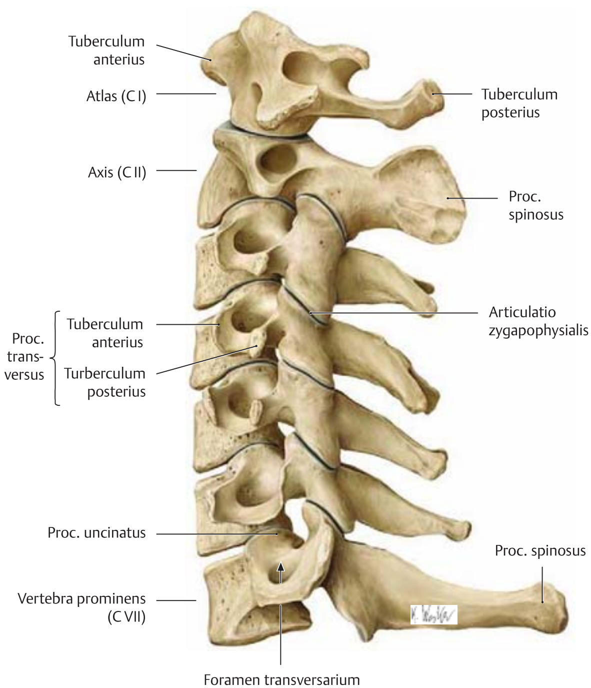
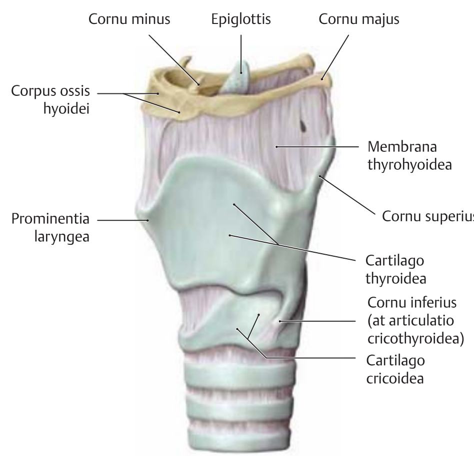


Table 37.1	Bones and joints of the neck	
Columna vertebralis cervicalis		p. 6
Os hyoideum		p. 539
Articulationes craniovertebrales	Articulatio atlantooccipitalis	p. 16
	Articulatio atlantoaxialis	
Uncovertebral joints		p. 15
Articulationes zygapophysialis (intervertebral facet)		p. 14
Larynx		p. 571

Fig. 37.2 **Bony structures of the neck**
Left lateral view.

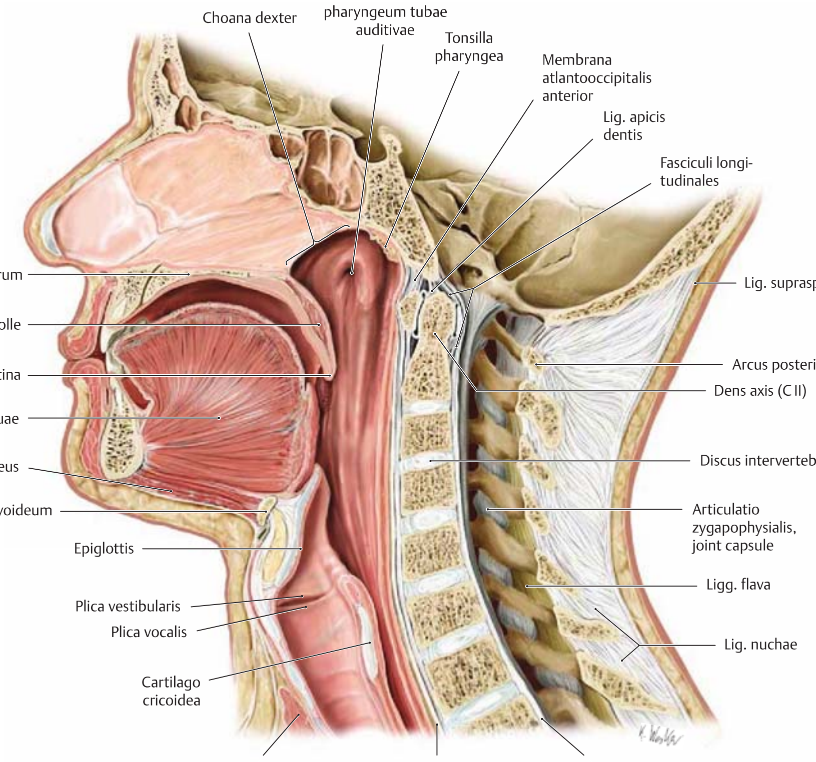


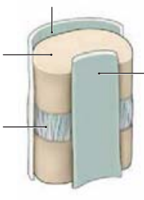
A Cervical spine. The seven vertebrae of the cervical spine are specialized for bearing the weight of the head.



B Os hyoideum and larynx. The os hyoideum provides a site for bony attachment for the supra- and infrahyoid muscles. *Note:* The larynx is suspended from the os hyoideum, primarily by the membrana thyrohyoidea.

Fig. 37.3 **Ligaments of the cervical spine**
Midsagittal section, viewed from the left side.
For the ligaments of the craniovertebral joints, see p. 16.

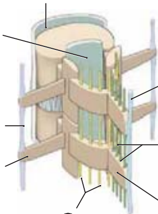




A Vertebral body ligaments.

Table 37.2 **Ligaments of the vertebral column**	
Vertebral body ligaments	**Vertebral arch ligaments**
A Lig. longitudinale anterior	① Lig. intertransversarium
P Lig. longitudinale posterior	② Ligg. flava
	③ Lig. interspinale
	④ Lig. supraspinale*

* In the columna vertebralis cervicalis, the lig. supraspinale broadens into the lig. nuchae.



B Vertebral arch ligaments.

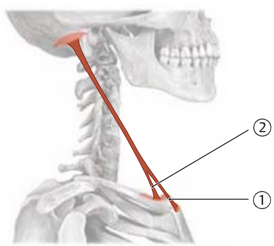
Overview & Superficial Muscles of the Neck

From a topographical standpoint, there are six major muscle groups in the neck. Functionally, however, the platysma belongs to the muscles of facial expression, m. trapezius belongs to the muscles of the shoulder girdle, and the nuchal muscles belong to the intrinsic back muscles. The mm. suboccipitales (short nuchal and craniovertebral joint muscles) are included in this chapter with the deep muscles of the neck.

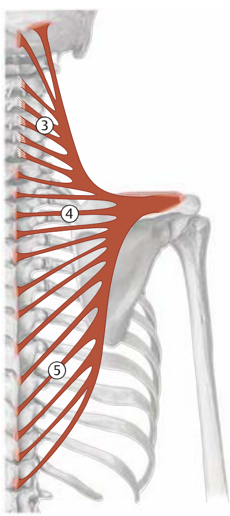
Table 37.3 **Classification of neck muscles**

I	**Superficial neck muscles**		**III**	**Suprahyoid muscles**	
	Platysma, m. sternocleidomastoideus, m. trapezius	Fig. 37.4		M. digastricus, m. geniohyoideus, m. mylohyoideus, m. stylohyoideus	Fig. 37.7A
II	**Nuchal muscles (intrinsic back muscles)**		**IV**	**Infrahyoid muscles**	
	⑥ M. semispinalis capitis ⑦ M. semispinalis cervicis	See p. 32		M. sternohyoideus, m. sternothyroideus, m. thyrohyoideus, m. omohyoideus	Fig. 37.7B
	⑧ M. splenius capitis ⑨ M. splenius cervicis	See p. 30	**V**	**Prevertebral muscles**	
	⑩ M. longissimus capitis ⑪ M. longissimus cervicis			M. longus capitis, m. longus coli, m. rectus capitis anterior and lateralis	Fig. 37.9A
	⑫ M. iliocostalis cervicis		**VI**	**Lateral (deep) neck muscles**	
	Mm. suboccipitales (short nuchal and craniovertebral joint muscles)	Fig. 37.9C		M. scalenus anterior, medius, and posterior	Fig. 37.9B

Fig. 37.4 **Superficial neck muscles**
See Table 37.4 for details.

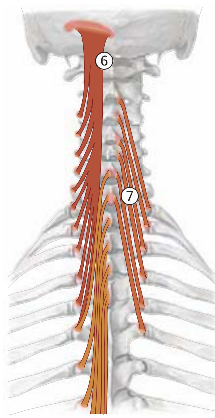


A M. sternocleidomastoideus.

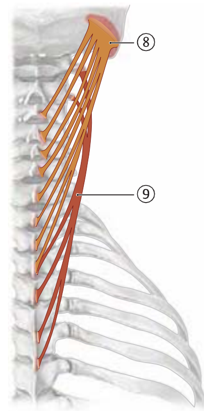


B M. trapezius.

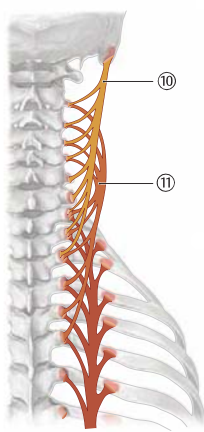
Fig. 37.5 **Nuchal muscles**



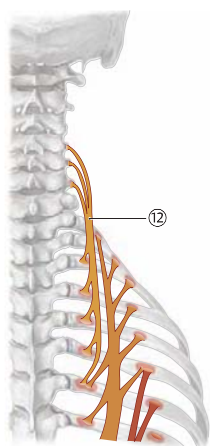
A Mm. semispinalis capitas and cervicis.



B M. splenius capitis and cervicis.

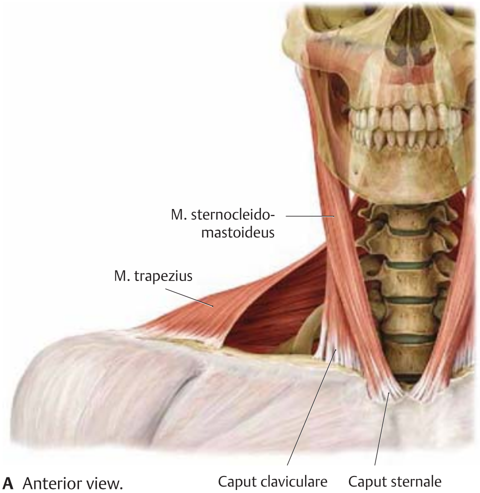


C M. longissimus capitas and cervicis.

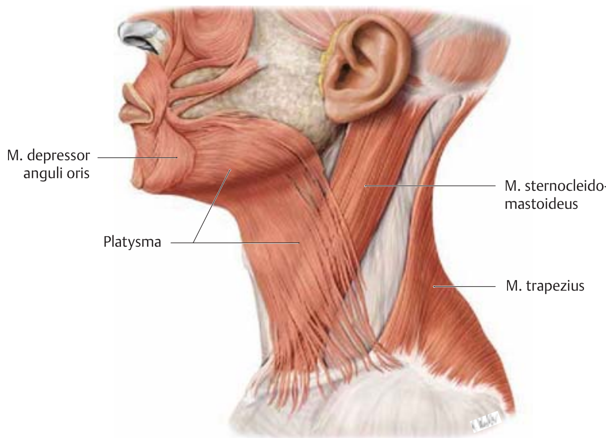


D M. ilio-costalis cervicis.

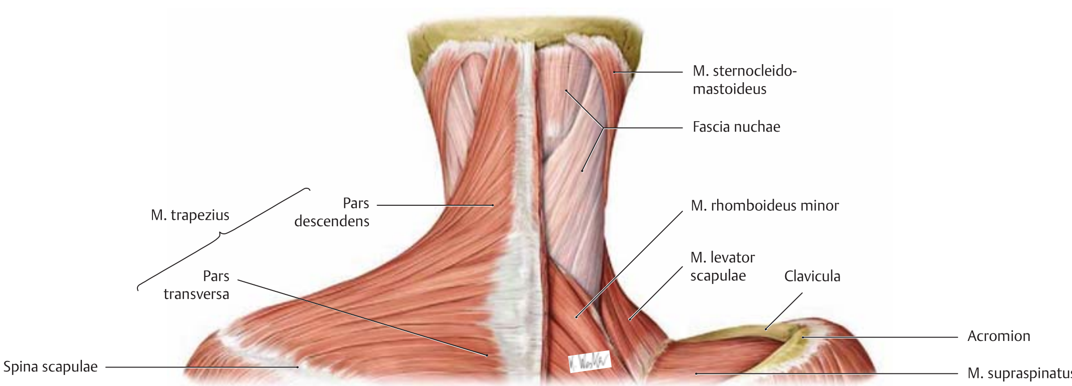
Fig. 37.6 Superficial musculature of the neck



A Anterior view.



B Left lateral view.



C Posterior view. *Removed:* M. trapezius (right side).

Table 37.4	**Superficial neck muscles**				
Muscle		**Origin**	**Insertion**	**Innervation**	**Action**
Platysma		Skin over lower neck and upper lateral thorax	Mandibula (inferior border), skin over lower face and angulus oris	R. cervicalis of n. facialis (CN VII)	Depresses and wrinkles skin of lower face and mouth, tenses skin of neck, aids forced depression of mandibula
M. sternocleido-mastoideus	① Caput sternale	Manubrium sterni	Os temporale (proc. mastoideus), os occipitale (linea nuchalis superior)	*Motor:* N. accessorius (CN IX) *Pain and proprioception:* Plexus cervicalis (C2, C3)	*Unilateral:* Tilts head to same side, rotates head to opposite side *Bilateral:* Extends head, aids in respiration when head is fixed
	② Caput claviculare	Clavicula (medial one third)			
M. trapezius	③ Pars descendens	Os occipitale, procc. spinosi of C I–C VII	Clavicula (lateral one third)		Draws scapula obliquely upward, rotates glenoid cavity inferiorly

* The pars transversa ④ and pars ascendens ⑤ are described on p. 276.

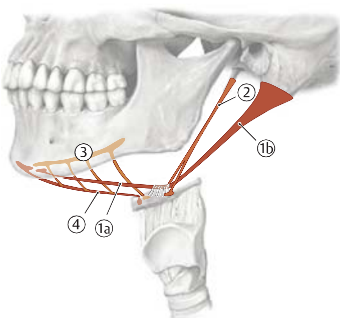
Suprahyoid & Infrahyoid Muscles of the Neck

Table 37.5 Suprahyoid muscles

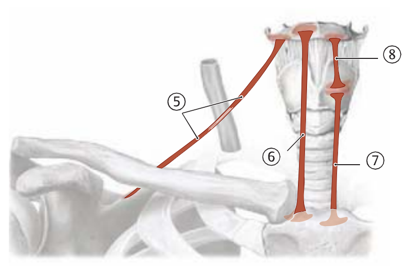
The suprahyoid muscles are also considered accessory muscles of mastication.

Muscle		Origin	Insertion		Innervation	Action
M. diagastricus	(1a) Venter anterior	Mandibula (Fossa digastrica)	Os hyoideum (corpus)	Via an intermediate tendon with a fibrous loop	N. mylohyoideus (from CN V_3)	Elevates hyoid bone (during swallowing), assists in opening mandibula
	(1b) Venter posterior	Os temporale (incisura mastoidea, medial to proc. mastoideus)			N. facialis (CN VII)	
② M. stylohyoideus		Os temporale (proc. styloideus)		Via a split tendon		
③ M. mylohyoideus		Mandibula (linea mylohyoidea)		Via median tendon of insertion (raphe mylohyoidea)	N. mylohyoideus (from CN V_3)	Tightens and elevates oral floor, draws hyoid bone forward (during swallowing), assists in opening mandibula and moving it side to side (mastication)
④ M. geniohyoideus		Mandibula (spina mentalis inferior)		Directly	R. ventralis of C1 via (via CN XII)	Draws hyoid bone forward (swallowing), assists in opening mandibula

Fig. 37.7 **Supra- and infrahyoid muscles**



A Suprahyoid muscles, left lateral view.



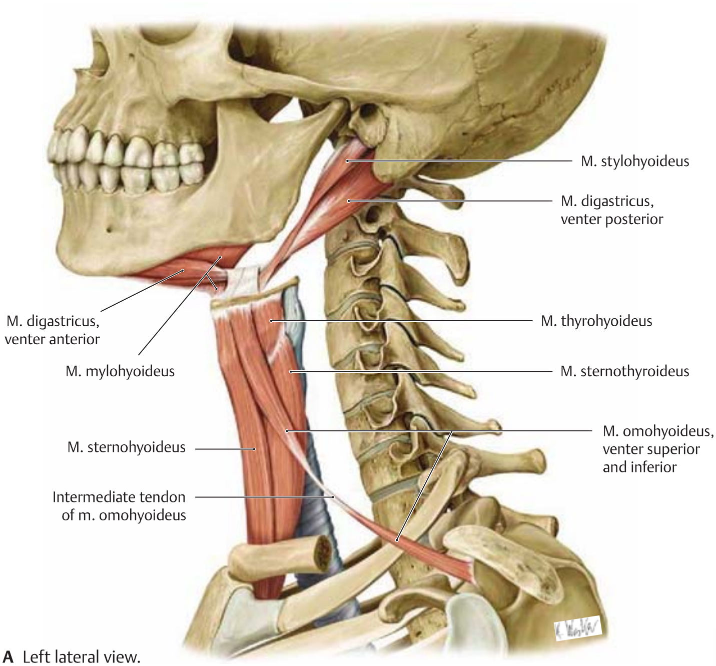
B Infrahyoid muscles, anterior view.

Table 37.6 Infrahyoid muscles

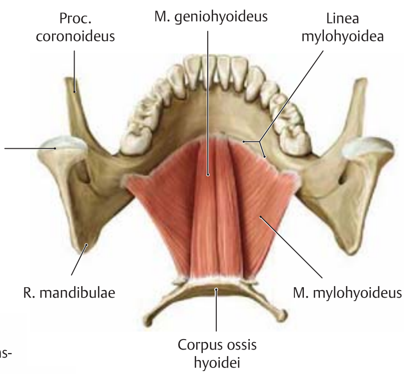
Muscle	Origin	Insertion	Innervation	Action
⑤ M omohyoideus	Scapula (margo superior)	Os hyoideum (corpus)	Ansa cervicalis of plexus cervicalis (C1–C3)	Depresses (fixes) hyoid, draws larynx and hyoid down for phonation and terminal phases of swallowing*
⑥ M. sternohyoideus	Manubrium sterni and articulatio sternoclaviculare (posterior surface)			
⑦ M sternothyroideus	Manubrium sterni (posterior surface)	Cartilago thyroidea (linea obliqua)	Ansa cervicalis (C2–C3)	
⑧ M. thyrohyoideus	Cartilago thyroidea (linea obliqua)	Os hyoideum (corpus)	C1 via n. hypoglossus (CN XII)	Depresses and fixes hyoid, raises the larynx during swallowing

* The m. omohyoideus also tenses the fascia cervicalis (with an intermediate tendon).

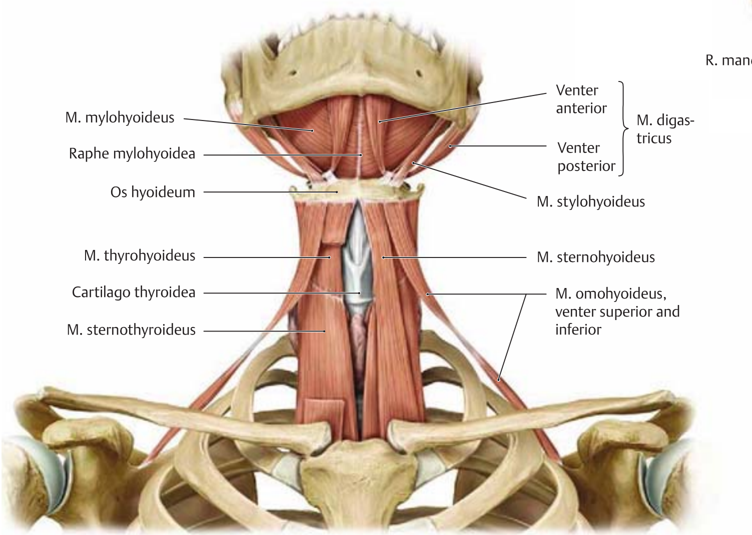
Fig. 37.8 **Supra- and infrahyoid muscles**



A Left lateral view.



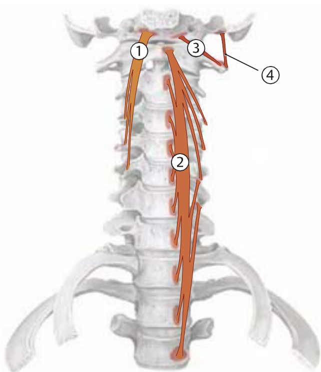
B M. mylohyoideus and m. geniohyoideus (oral floor), posterosuperior view.



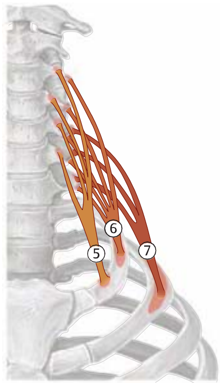
C Anterior view. M. sternohyoideus has been cut (right).

Deep Muscles of the Neck

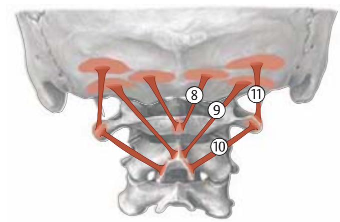
Fig. 37.9 **Deep muscles of the neck**



A Prevertebral muscles, anterior view.



B Mm. scaleni, anterior view.

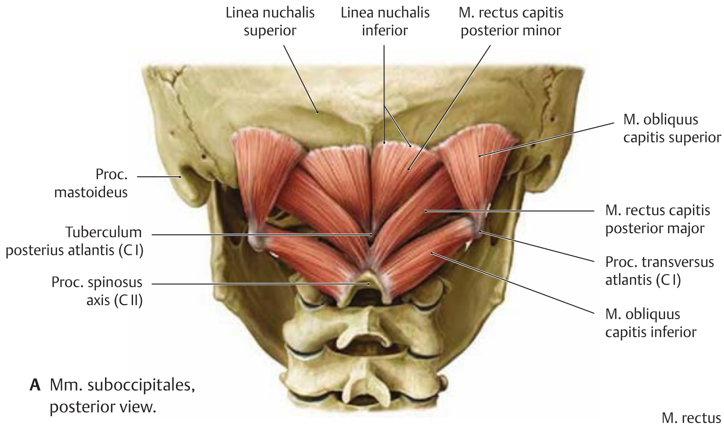


C Mm. suboccipitales, posterior view.

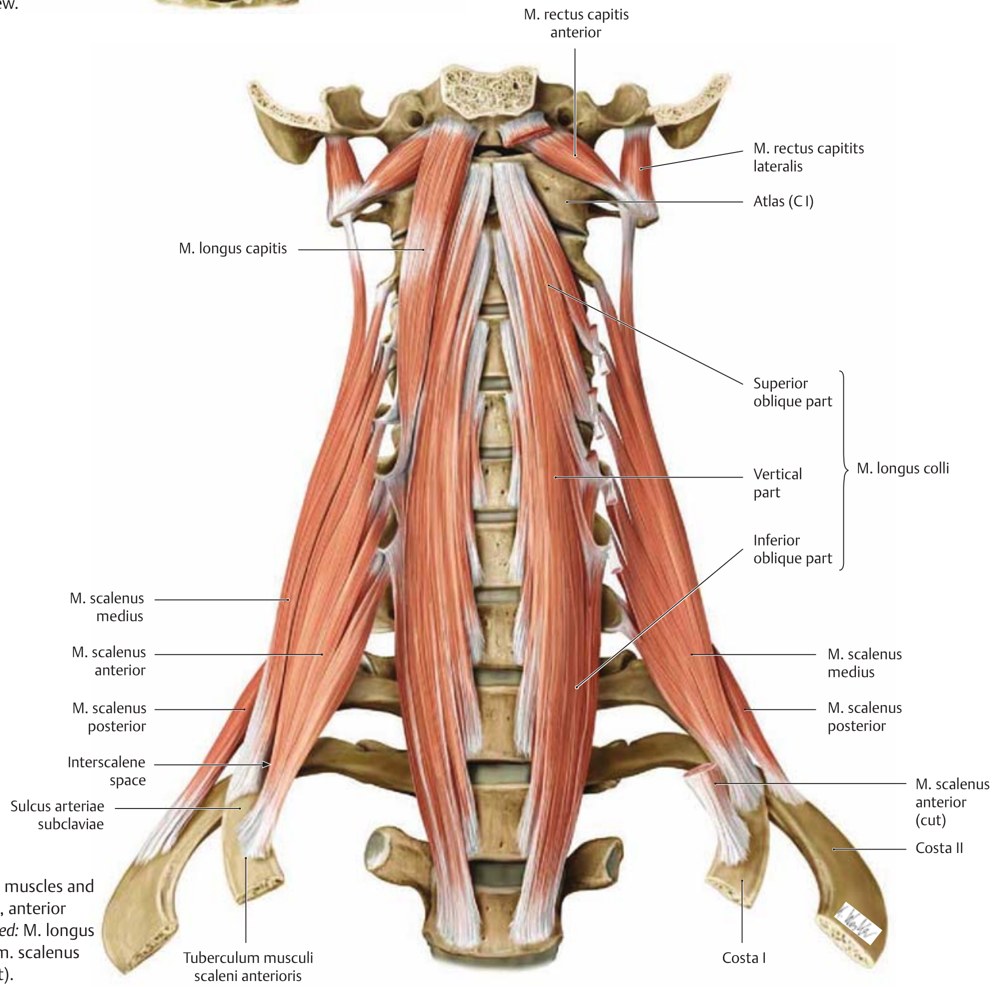
Table 37.7 **Deep muscles of the neck**

<table>
<tr><th colspan="2">Muscle</th><th>Origin</th><th>Insertion</th><th>Innervation</th><th>Action</th></tr>
<tr><td colspan="6">Prevertebral muscles</td></tr>
<tr><td colspan="2">① M. longus capitis</td><td>C III–C VI (tuberculum anterius of proc. transversus)</td><td>Os occipitale (pars basilaris)</td><td>Direct branches from plexus cervicalis (C1–C3)</td><td>Flexion of head at atlanto-occipital joints</td></tr>
<tr><td rowspan="3">② M. longus colli</td><td>Pars verticalis (intermedia)</td><td>C V–T III (tuberculum anterius of corpus vertebrae)</td><td>C I–C IV (anterior surfaces)</td><td rowspan="3">Direct branches from plexus cervicalis (C2–C6)</td><td rowspan="3">Unilateral: Tilts and rotates cervical spine to opposite side
Bilateral: Forward flexion of cervical spine</td></tr>
<tr><td>Pars obliqua superior</td><td>C III–C V (tuberculum anterius of proc. transversus)</td><td>Atlas (tuberculum anterius)</td></tr>
<tr><td>Pars obliqua inferior</td><td>T I–T III (anterior surfaces of corpus vertebrae)</td><td>C V–C VI (tuberculum anterius of proc. transversus)</td></tr>
<tr><td colspan="2">③ M. rectus capitis anterior</td><td>C I (massa lateralis atlantis)</td><td>Os occipitale (basilar part)</td><td rowspan="2">R. ventralis of C1 and C2</td><td rowspan="2">Unilateral: Lateral flexion at the atlanto-occipital joint
Bilateral: Flexion at the atlanto-occipital joint</td></tr>
<tr><td colspan="2">④ M. rectus capitis lateralis</td><td>C I (proc. transversus)</td><td>Os occipitale (pars basilaris, lateral to proc. condylaris)</td></tr>
<tr><td colspan="6">MM. scaleni</td></tr>
<tr><td colspan="2">⑤ M. scalenus anterior</td><td>C III–C VI (tuberculum anterius of proc. transversus)</td><td>Costa I (tuberculum musculi scaleni)</td><td rowspan="3">Direct branches from plexus cervicalis and plexus brachialis (C3–C8)</td><td rowspan="3">With ribs mobile: Elevates upper ribs (during forced inspiration)
With ribs fixed: Bends cervical spine to same side (unilateral), flexes neck (bilateral)</td></tr>
<tr><td colspan="2">⑥ M. scalenus medius</td><td>C I–C II (proc. transversus), C III–C VII (tuberculum posterius of proc. transversus)</td><td>Costa I (posterior to sulcus arteriae subclaviae)</td></tr>
<tr><td colspan="2">⑦ M. scalenus posterior</td><td>C V–C VII (tuberculum posterius of proc. transversus)</td><td>Costa II (outer surface)</td></tr>
<tr><td colspan="6">Mm. suboccipitales (short nuchal and craniovertebral joint muscles)</td></tr>
<tr><td colspan="2">⑧ M. rectus capitis posterior minor</td><td>C I (tuberculum posterius)</td><td>Os occipitale (inner third of linea)</td><td rowspan="4">R. dorsalis of C1 (n. suboccipitalis)</td><td rowspan="3">Unilateral: Rotates head to same side
Bilateral: Extends head</td></tr>
<tr><td colspan="2">⑨ M. rectus capitis posterior major</td><td rowspan="2">C II (proc. spinosus)</td><td>Os occipitale (middle third of linea nuchalis inferior)</td></tr>
<tr><td colspan="2">⑩ M. obliquus capitis inferior</td><td>C I (proc. transversus)</td></tr>
<tr><td colspan="2">⑪ M. obliquus capitis superior</td><td>C I (proc. transversus)</td><td>Os occipitale (above insertion of m. rectus capitis posterior major)</td><td>Unilateral: Tilts head to same side, rotates it to opposite side
Bilateral: Extends head</td></tr>
</table>

Fig. 37.10 Deep muscles of the neck



A Mm. suboccipitales, posterior view.



B Prevertebral muscles and mm. scaleni, anterior view. *Removed:* M. longus capitis and m. scalenus anterior (left).

Arteries & Veins of the Neck

Fig. 37.11 **Arteries of the neck**
Left lateral view. The structures of the neck are primarily supplied by a. carotis externa (anterior branches) and a. subclavia (a. vertebralis, truncus thyrocervicalis, and truncus costocervicalis).

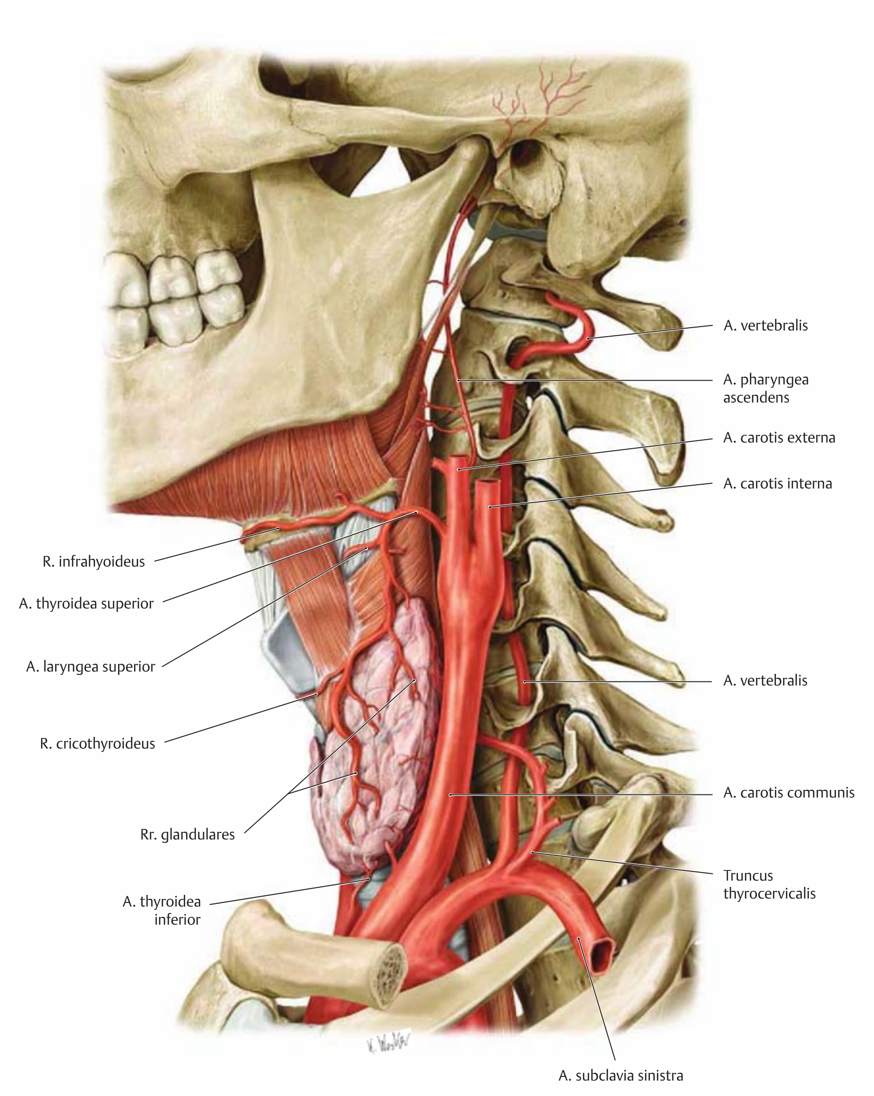
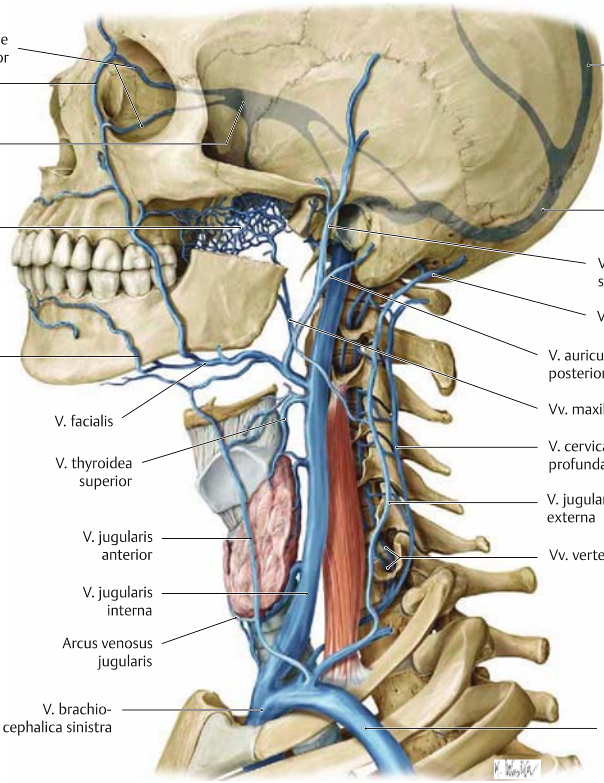
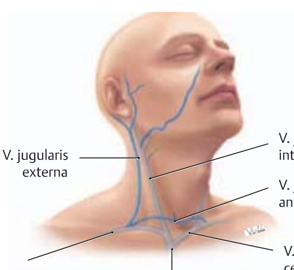


Fig. 37.12 Veins of the neck
Left lateral view. The principal veins of the neck are the vv. jugulares interna, externa, and anterior.



Clinical

Impeded blood flow and veins of the neck
When clinical factors (e.g., chronic lung disease, mediastinal tumors, or infections) impede the flow of blood to the right heart, blood dams up in the v. cava superior, and consequently, the vv. jugulares. This causes conspicuous swelling in the vv. jugulares (and sometimes more minor veins).



Innervation of the Neck

Table 37.8 Branches of the spinal nerves in the neck

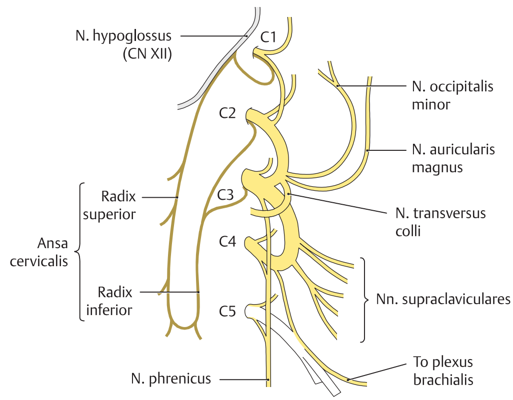
Posterior (dorsal) ramus

	Nerve	Sensory function	Motor function
C1	N. supocciptalis	No C1 dermatome	Innervate intrinsic nuchal muscles
C2	N. occipitalis major	Innervate C2 dermatome	
C3	N. occipitalis tertius	Innervate C3 dermatome	

Anterior (ventral) ramus

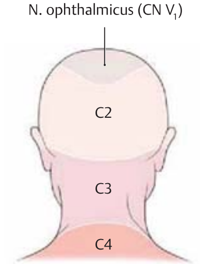
	Sensory branches	Sensory function	Motor branches	Motor function
C1	—	—	Form ansa cervicalis (pars motorica of plexus cervicalis)	Innervate infrahyoid muscles (except m. thyrohyoideus)
C2	N. occipitalis minor	Form pars sensorica of plexus cervicalis, innervate anterior and lateral neck		
C2–C3	N. auricularis major			
	N. transversus colli			
C3–C4	Nn. suprasclaviculares			
			Contribute to n. phrenicus*	Innervate diaphragma and pericardium*

* The Radices ventrales of C3–C5 combine to form the n. phrenicus (see p. 54).

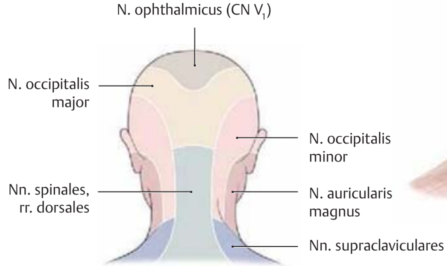


Branching of plexus cervicalis.

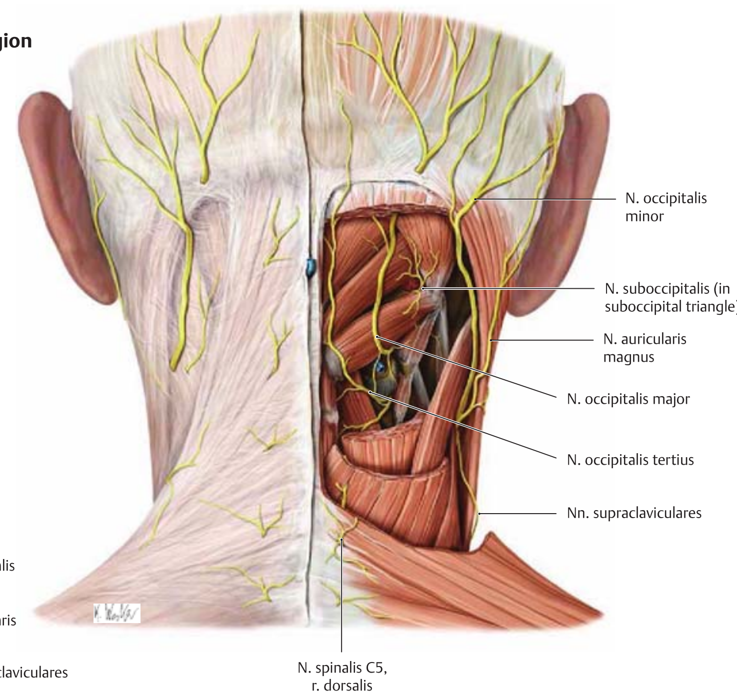
Fig. 37.13 **Innervation of the nuchal region**
Posterior view.



A Dermatomes.

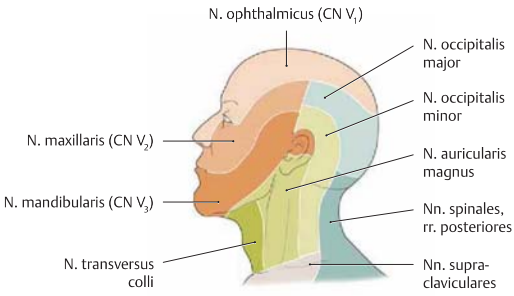


B Cutaneous nerve territories.

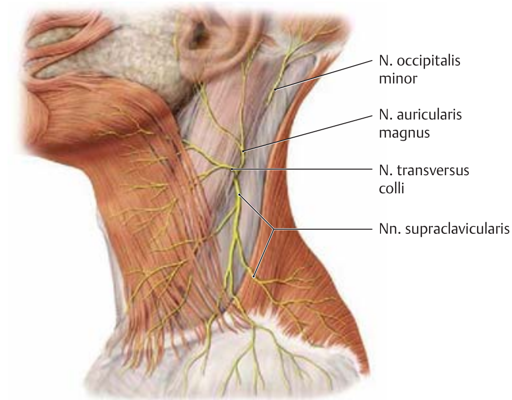


C Spinal nerve branches.

Fig. 37.14 Sensory innervation of the anterolateral neck
Left lateral view.

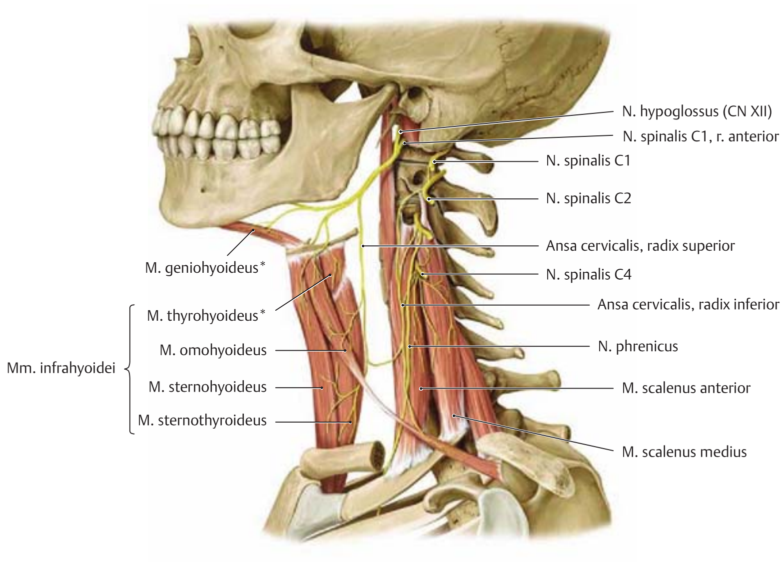


A Cutaneous nerve territories. N. trigeminus (orange), posterior rami (blue), anterior rami (yellow).



B Sensory branches of plexus cervicalis.

Fig. 37.15 Motor innervation of the anterolateral neck
Left lateral view.



* Innervated by the ramus anterior of C1 (distributed by n. hypoglossus).

Larynx: Cartilage & Structure

Fig. 37.16 **Laryngeal cartilages**
Left lateral view. The larynx consists of five laryngeal cartilages: cartilago epiglottica, cartilago thyroidea, cartilago cricoidea, and the paired cartilago arytenoidea and cartilago corniculata. They are connected to each other, trachea, and os hyoideum.

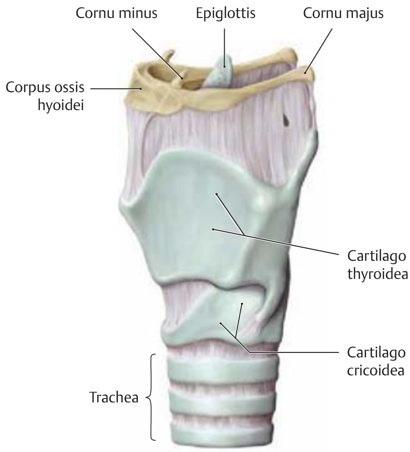


Fig. 37.17 **Cartilago epiglottica**
The elastic cartilago epiglottica comprises the internal skeleton of the epiglottis, providing resilience to return it to its initial position after swallowing.

A Lingual (anterior) view.

B Left lateral view.

C Laryngeal (posterior) view.

Fig. 37.18 **Cartilago thyroidea**
Left oblique view.

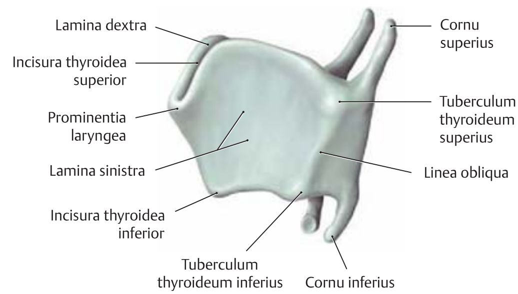
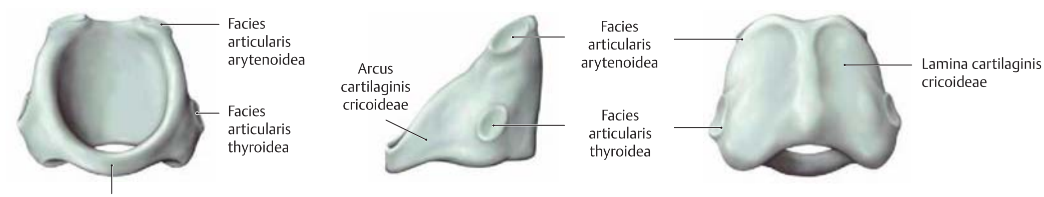


Fig. 37.19 **Cartilago cricoidea**

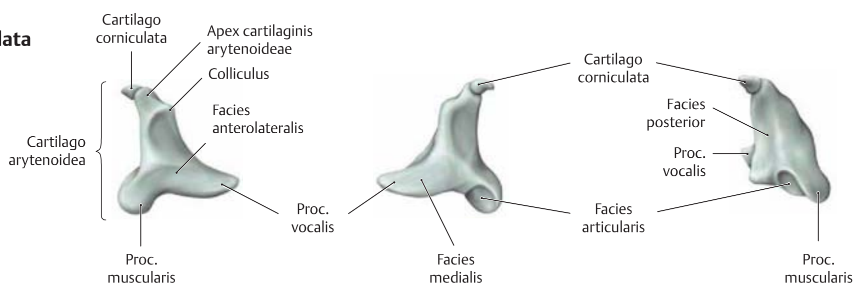


A Anterior view.

B Left lateral view.

C Posterior view.

Fig. 37.20 **Cartilagines arytenoidea and corniculata**
Right cartilages.

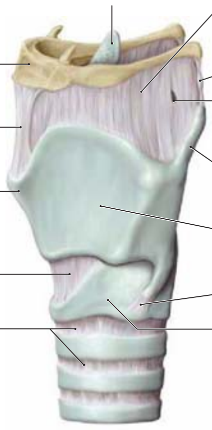


A Right lateral view.

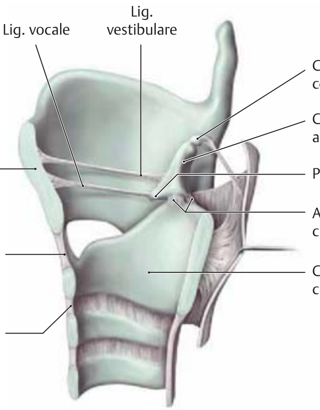
B Medial view.

C Posterior view.

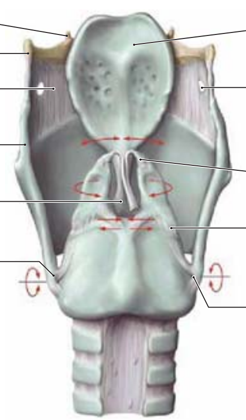
Fig. 37.21 **Structure of the larynx**



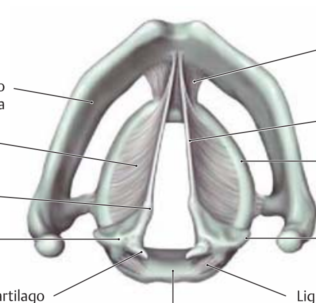
A Left anterior oblique view.



B Sagittal section, viewed from the left medial aspect. The cartilago arytenoidea alters the position of the vocal folds during phonation.



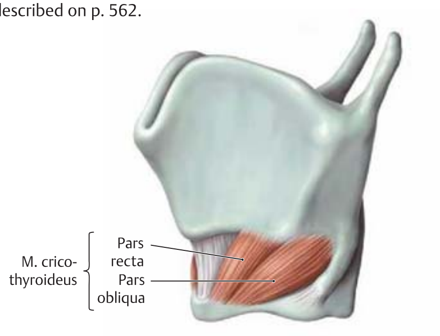
C Posterior view. Arrows indicate the directions of movement in the various joints.



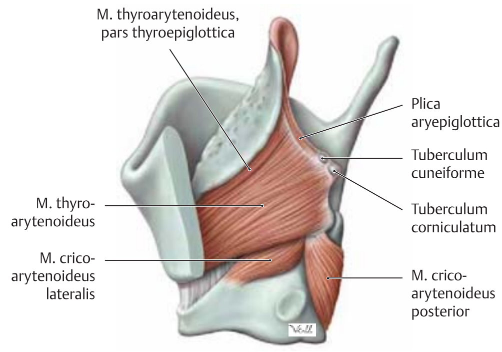
D Superior view.

Larynx: Muscles & Levels

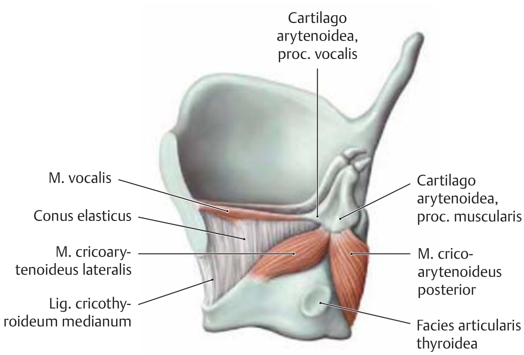
Fig. 37.22 **Laryngeal muscles**
The laryngeal muscles move the laryngeal cartilages relative to one another, affecting the tension and/or position of the vocal folds. Muscles that move the larynx as a whole (infra- and suprahyoid muscles) are described on p. 562.



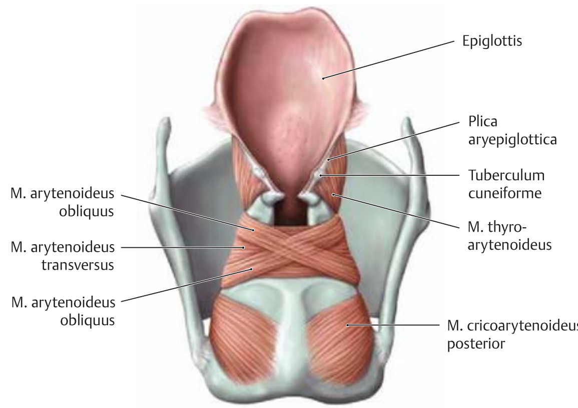
A Extrinsic laryngeal muscles, left lateral oblique view.



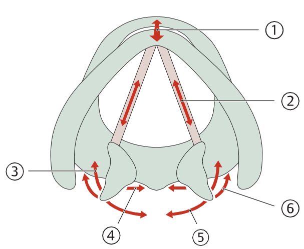
B Intrinsic laryngeal muscles, left lateral view. *Removed:* Cartilago thyroidea (left half). *Revealed:* Epiglottis and m. thyroarytenoideus.



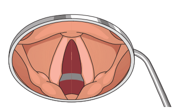
C Left lateral view with the epiglottis removed.



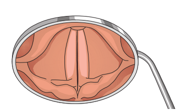
D Posterior view.



A Laryngeal muscles, superior view.



B Open rima glottidis.

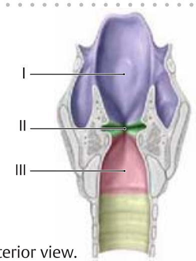


C Closed rima glottidis.

Table 37.9 **Actions of the laryngeal muscles**

Muscle	Action	Effect on rima glottidis
① M. cricothyroideus*	Tightens the plicae vocales	None
② M. vocalis		
③ M. thyroarytaenoideus	Adducts the plicae vocales	Closes
④ M. arytaenoideus transversus		
⑤ M. cricoarytaenoideus posterior	Abducts the plicae vocales	Opens
⑥ M. cricoarytaenoideus lateralis	Adducts the plicae vocales	Closes

* The m. cricothyroideus is the only extrinsic laryngeal muscle.

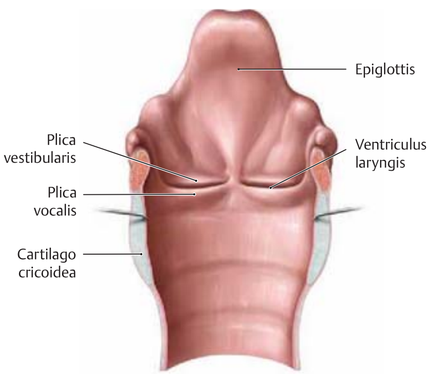


Posterior view.

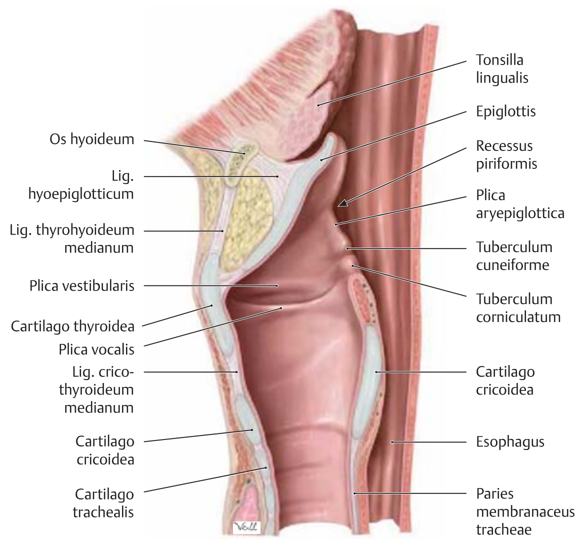
Table 37.10 Levels of the larynx

Level	Space	Extent
I	Supraglottic space (vestibulum laryngis)	Laryngeal inlet (aditus laryngis) to plicae vestibulares
II	Transglottic space (cavitas laryngis intermedia)	Plicae vestibulares across ventriculus laryngis (lateral evagination of mucosa) to plicae vocales
III	Subglottic space (cavitas infraglottica)	Plicae vocales to inferior border of cartilago cricoidea

Fig. 37.23 Cavitas laryngis



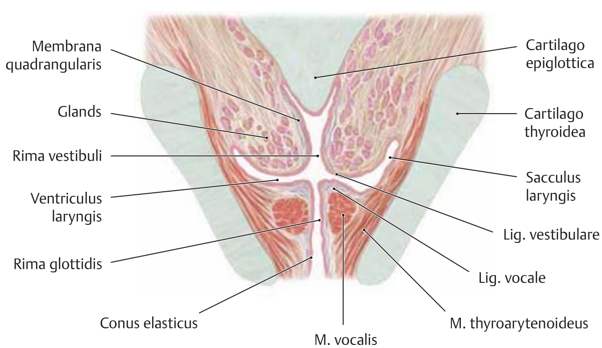
A Posterior view with the larynx splayed open.



B Midsagittal section viewed from the left side.

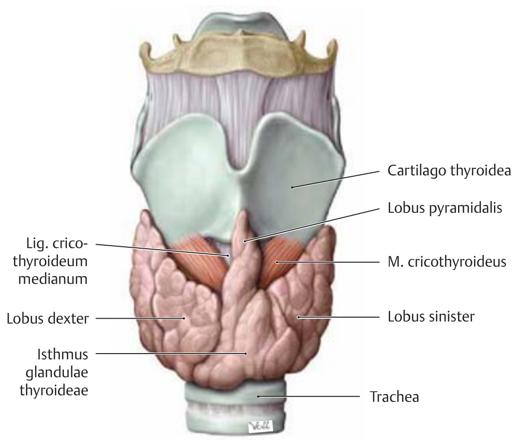
Fig. 37.24 Plicae vestibularis and vocalis

Coronal section, superior view.

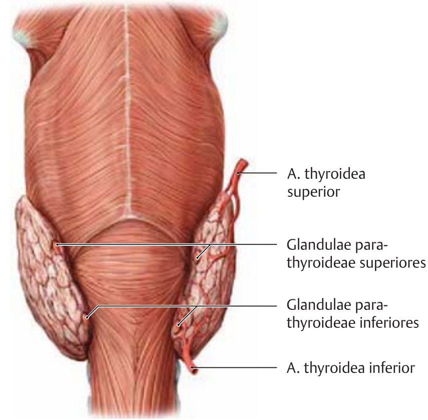


Neurovasculature of the Larynx, Thyroid & Parathyroids

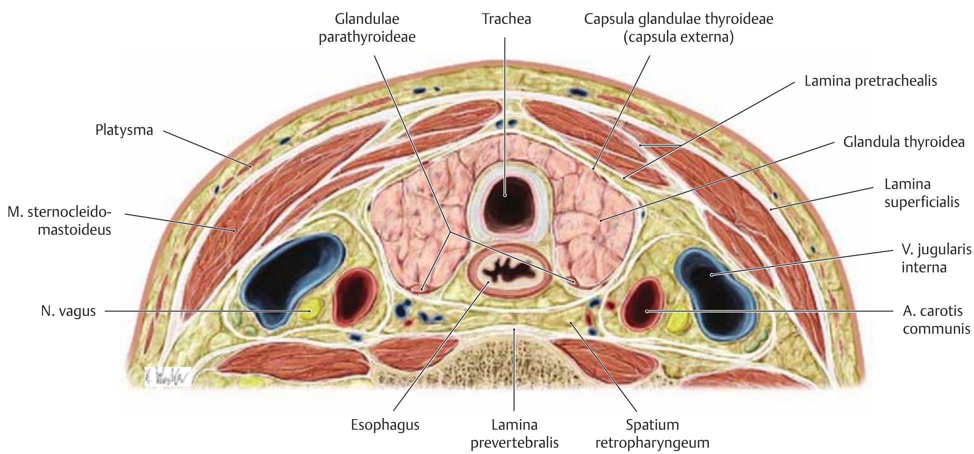
Fig. 37.25 Glandulae thyroidea and parathyroidea



A Glandula thyroidea, anterior view.



B Glandulae thyroidea and parathyroidea, posterior view.



C Topographical relations of glandulae thyroidea and parathyroidea. See p. 577 for the layers of fascia cervicalis.

Fig. 37.26 **Arteries and nerves**
Anterior view.

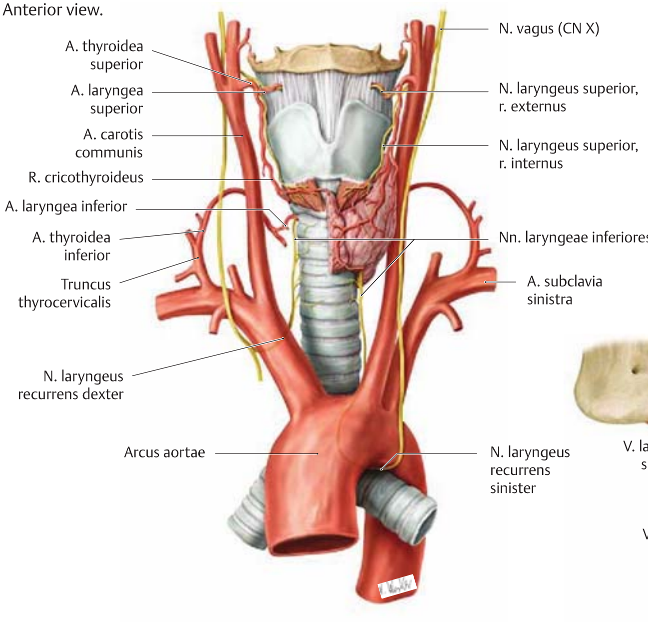


Fig. 37.27 **Veins**
Left lateral view. *Note:* The v. thyroidea inferior generally drains into the left v. brachiocephalica.

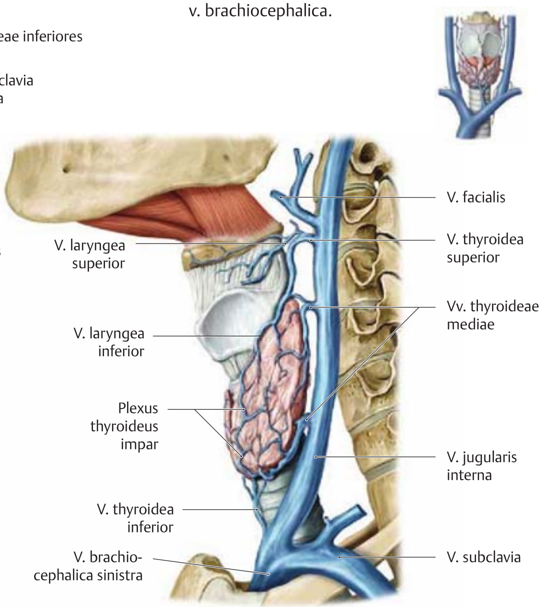
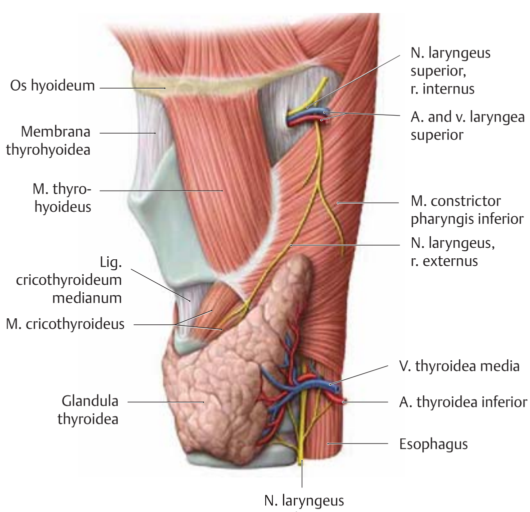
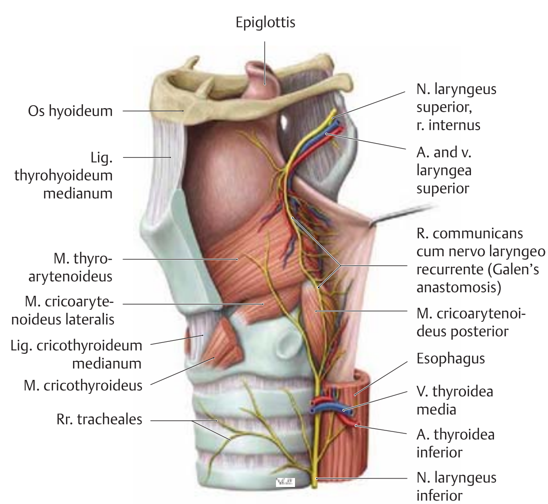


Fig. 37.28 **Neurovasculature**
Left lateral view.

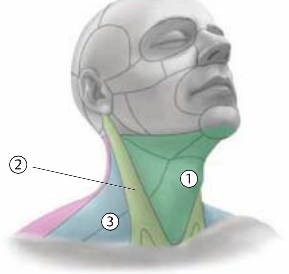


A Superficial layer.

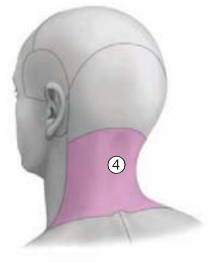


B Deep layer. *Removed:* M. cricothyroideus and left lamina of cartilago thyroidea. *Retracted:* Pharyngeal mucosa.

Topography of the Neck: Regions & Fascia



A Right anterior oblique view.

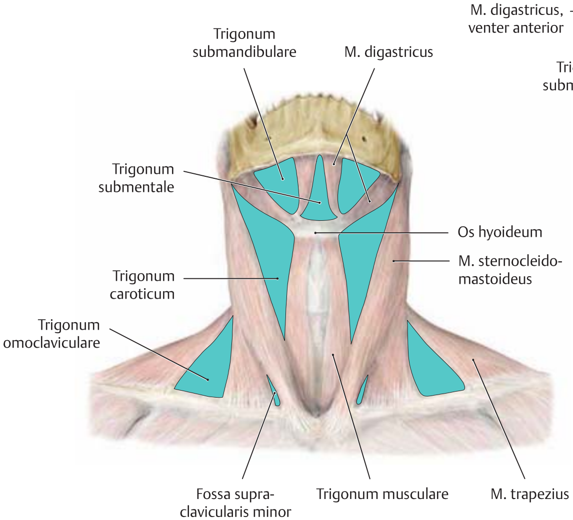


B Right posterior oblique view.

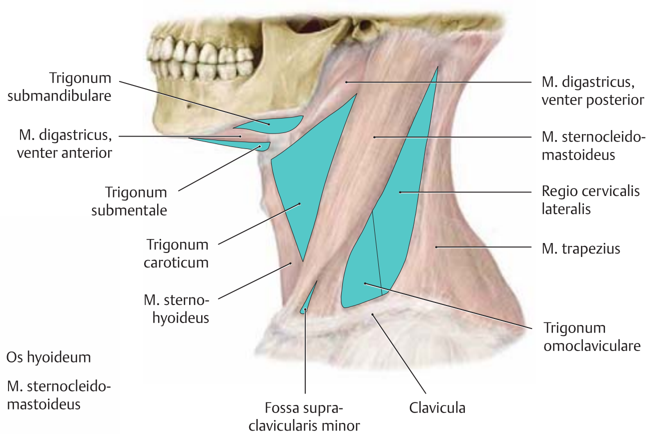
Fig. 37.29 **Cervical regions**

Table 37.11	**Regions of the neck**	
Region	**Divisions**	**Contents**
① Trigonum cervicale anterius	Trigonum submandibulare (digastric)	Glandula submandibularis and nll.submandibulares, n. hypoglossus (CN XII), a. and v. facialis
	Trigonum submentale	Nll. submentales
	Muscular triangle	M. sternothyroideus and m. sternohyoideus, glanula thyroidea and glandula parotidea
	Trigonum caroticum	Bifurcatio carotidis, glomus caroticum, n. hypoglossus (CN XII) and n. vagus (CN X)
② Regio sternocleidomastoidea*		M. sternocleidomastoideus, a. carotis, v. jugularis interna, n. vagus (CN X), nll. jugulares laterales
③ Regio cervicalis lateralis (trigonum cervicale posterius)	Trigonum omoclaviculare	A. subclavia, a. subscapularis, nll. supraclaviculares
	Trigonum occipitale	N. accessorius (CN XI), trunci of plexus brachialis, a. transversa cervicis, plexus cervicalis (rr. dorsales)
④ Regio cervicalis posterior		Nuchal muscles, a. vertebralis, plexus cervicalis

* The regio sternocleidomastoidea also contains the fossa supraclavicularis minor.



A Anterior view.

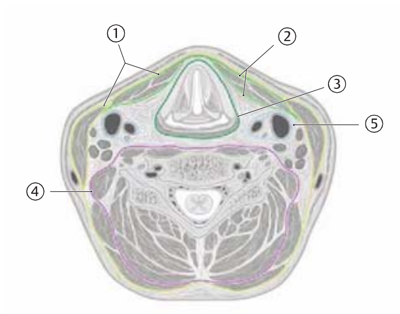


B Left lateral view.

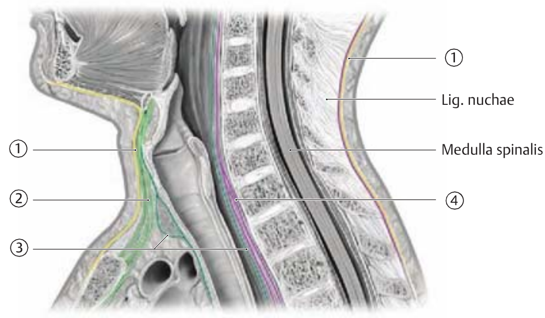
Table 37.12 Fascia cervicalis profunda

The fascia cervicalis profunda is divided into four laminae that enclose the structures of the neck.

Layer	Lamina	Type of fascia	Description
① Fascia investiens	Lamina superficialis	Muscular	Envelopes entire neck; splits to enclose m. sternocleidomastoideus and m. trapezius
Pretracheal layer	② Lamina pretrachealis	Muscular	Encloses infrahyoid muscles
Pretracheal layer	③ Lamina visceralis	Visceral	Surrounds glandula thyroidea, larynx, trachea, pharynx, and esophagus
④ Prevertebral layer	Lamina prevertebralis	Muscular	Surrounds columna vertebralis cervicalis and associated muscles
⑤ Vagina carotica		Neurovascular	Encloses common a. carotis, v. jugularis interna, and n. vagus

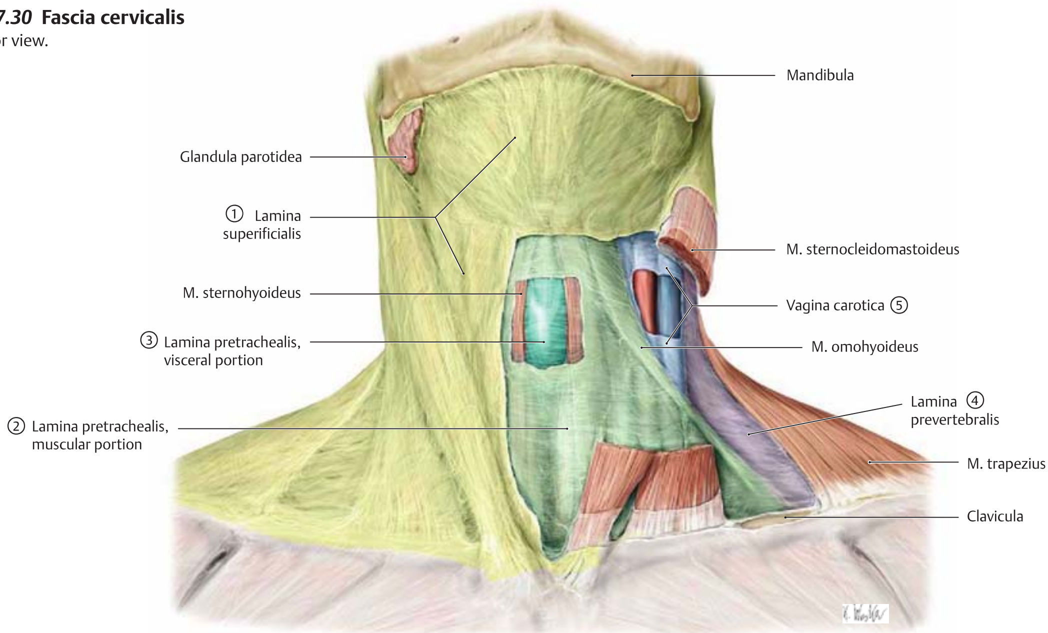


A Transverse section at level of C V vertebra.



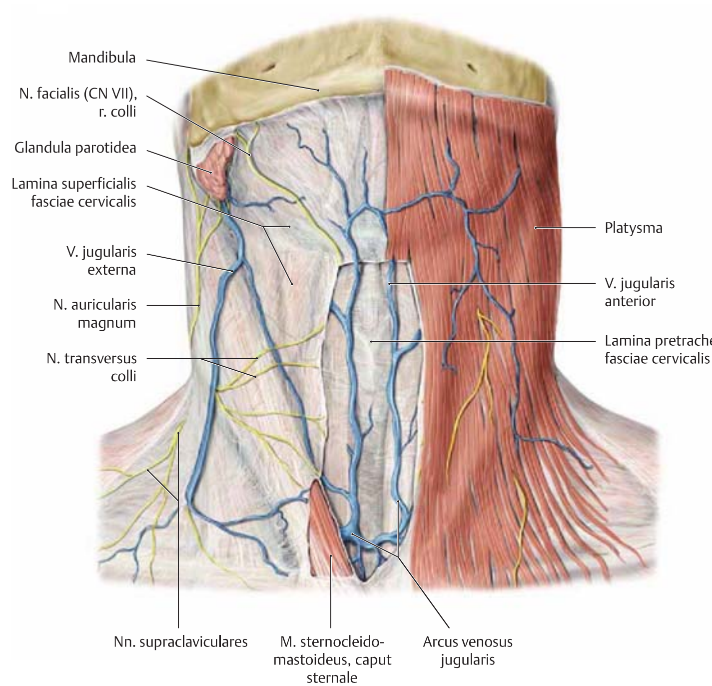
B Midsagittal section, left lateral view.

Fig. 37.30 **Fascia cervicalis**
Anterior view.

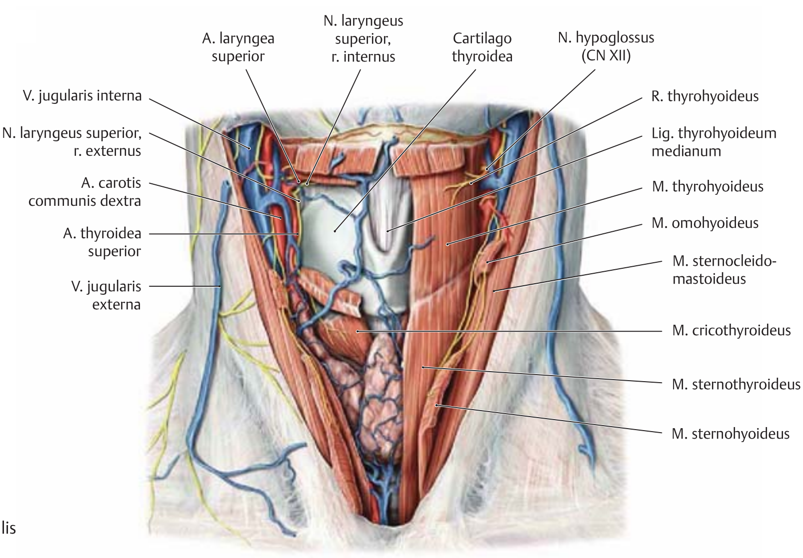


Topography of the Anterior Cervical Region

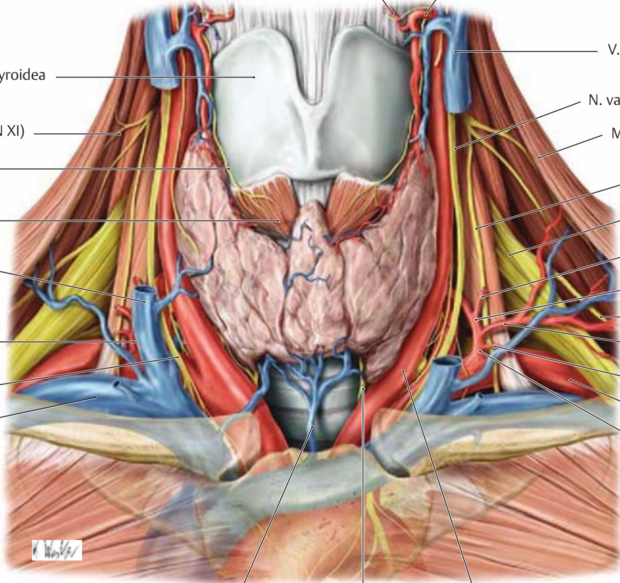
Fig. 37.31 **Regio cervicalis anterior**
Anterior view.



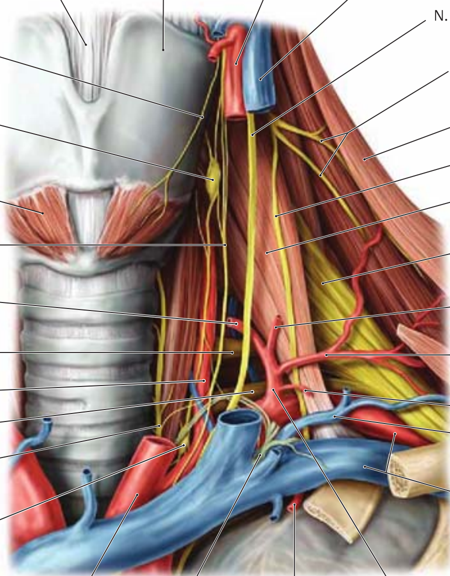
A Superficial layer. *Removed:* Subcutaneous platysma (right side) and lamina superficialis of fascia cervicalis (center).



B Deep layer. *Removed:* Lamina pretrachealis (middle layer of fascia cervicalis).



C Deep anterior cervical region.



D Root of the neck.

Topography of the Anterior & Lateral Cervical Regions

Fig. 37.32 **Trigonum caroticum**
Right lateral view.

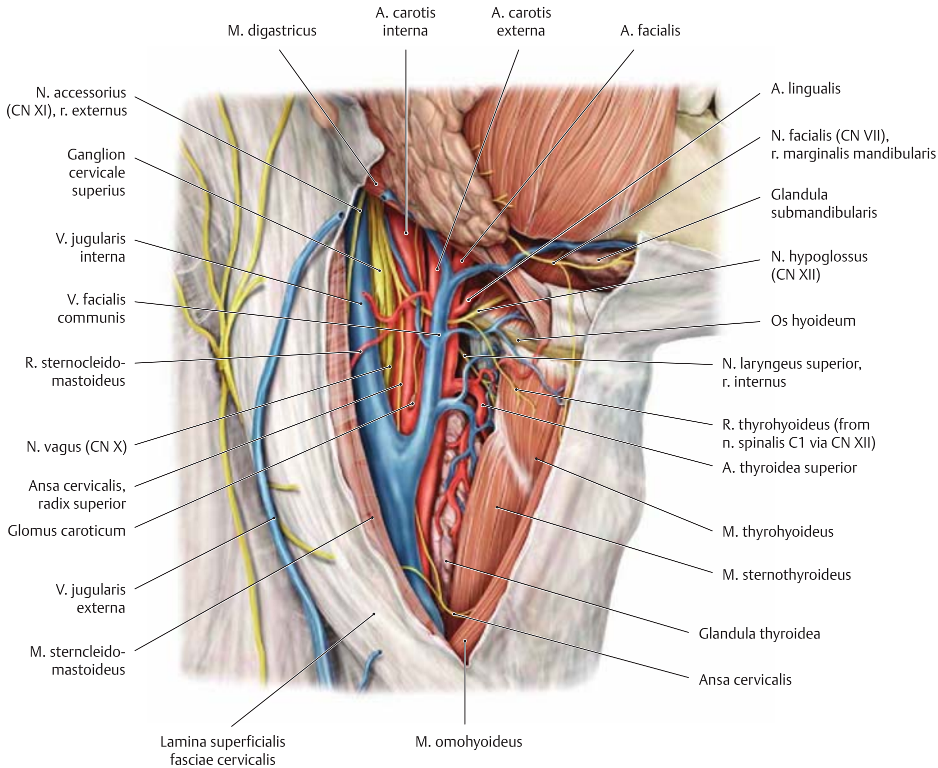
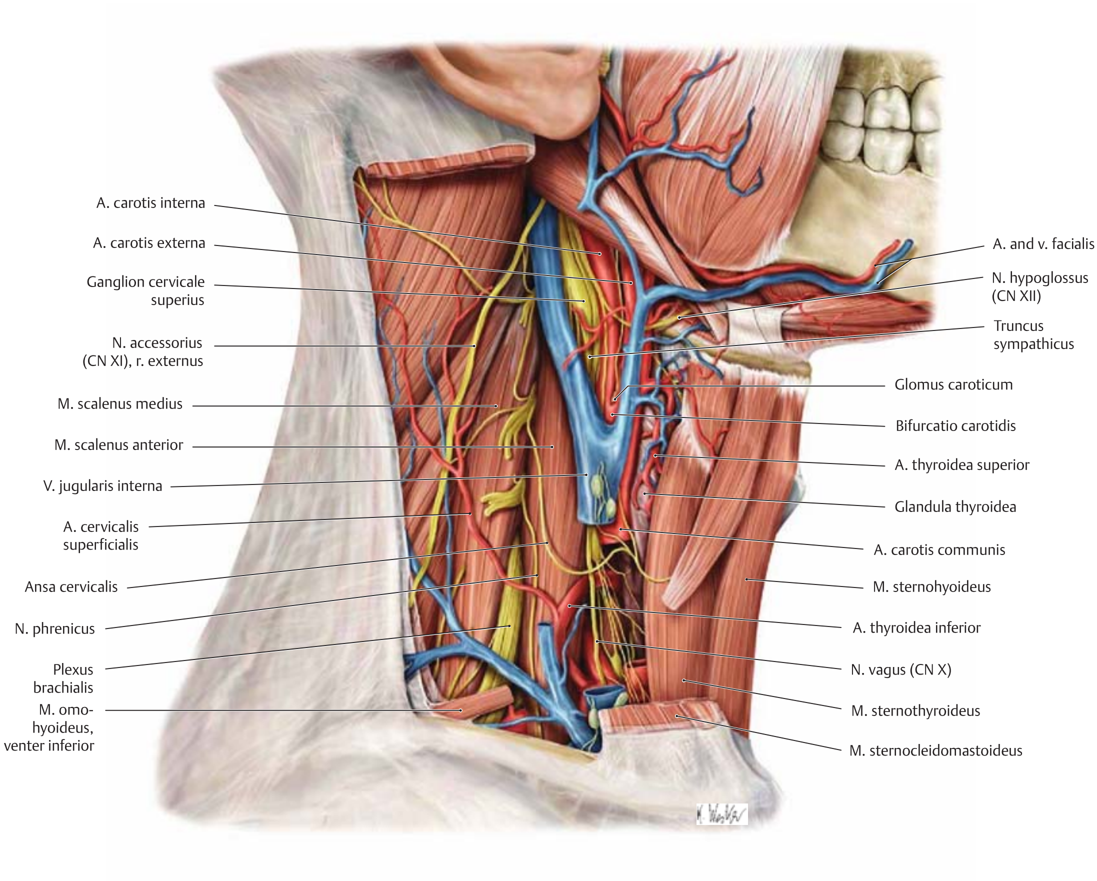
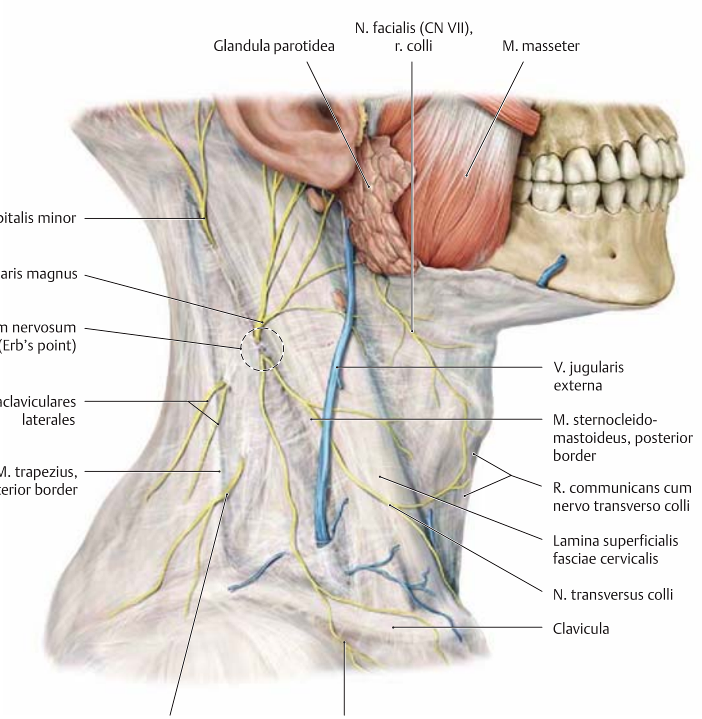


Fig. 37.33 **Regio cervicalis lateralis**
Right lateral view with m. sternocleidomastoideus windowed.

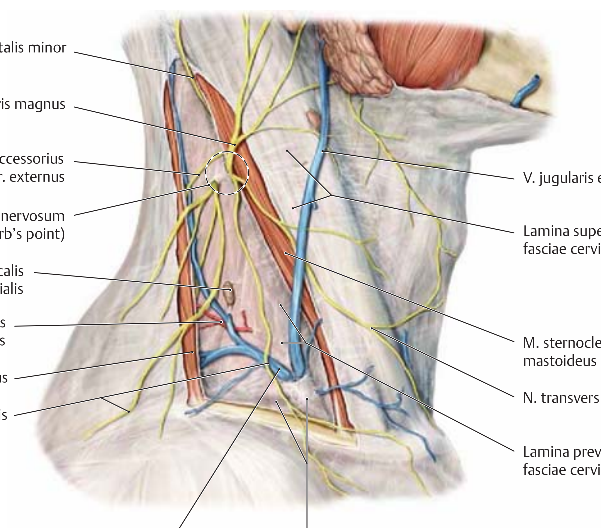


Topography of the Lateral Cervical Region

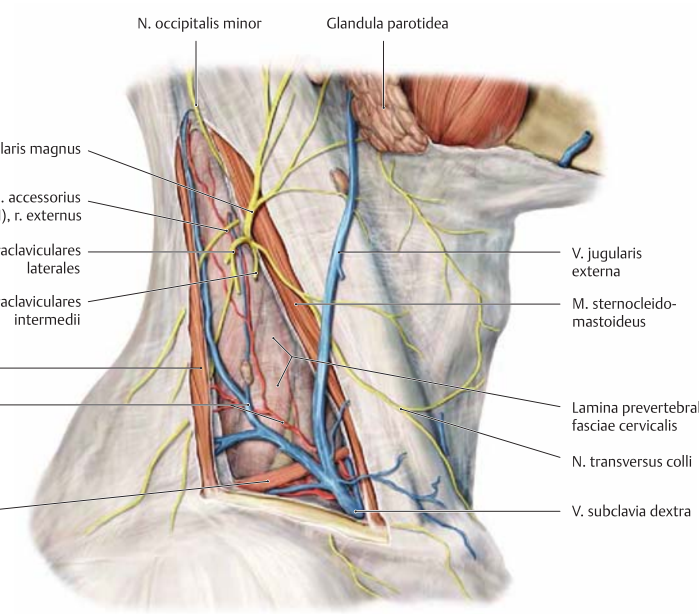
Fig. 37.34 **Regio cervicalis lateralis**
Right lateral view. The contents of regio cervicalis lateralis are found in Fig. 37.33.



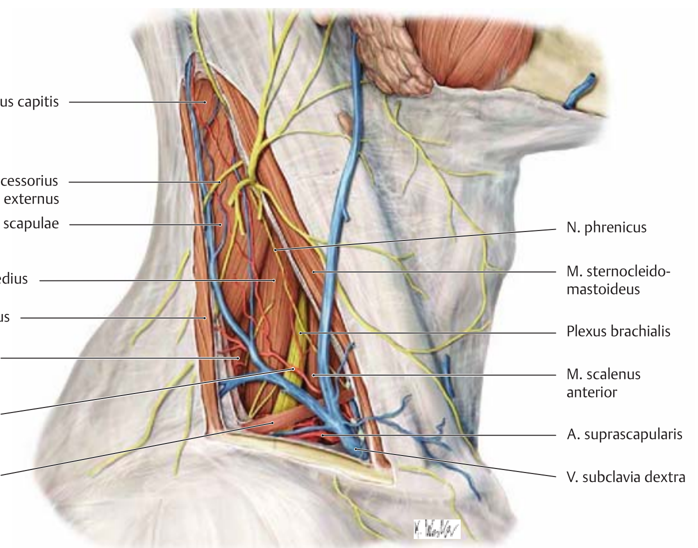
A Subcutaneous layer.



B Subfascial layer. *Removed:* Lamina superficialis of fascia cervicalis.



C Deep layer. *Removed:* Lamina pretrachealis of fascia cervicalis. *Revealed:* M. omohyoideus, trigonum omoclaviculare.



D Deepest layer. *Removed:* Lamina prevertebralis of fascia cervicalis. *Revealed:* Muscular floor of regio cervicalis lateralis, plexus brachialis and n. phrenicus.

Topography of the Posterior Cervical Region

Fig. 37.35 **Regiones occipitalis and cervicalis posterior**
Posterior view. Subcutaneous layer (left), subfascial layer (right). The occiput is technically a region of the head, but it is included here due to the continuity of the vessels and nerves from the neck.

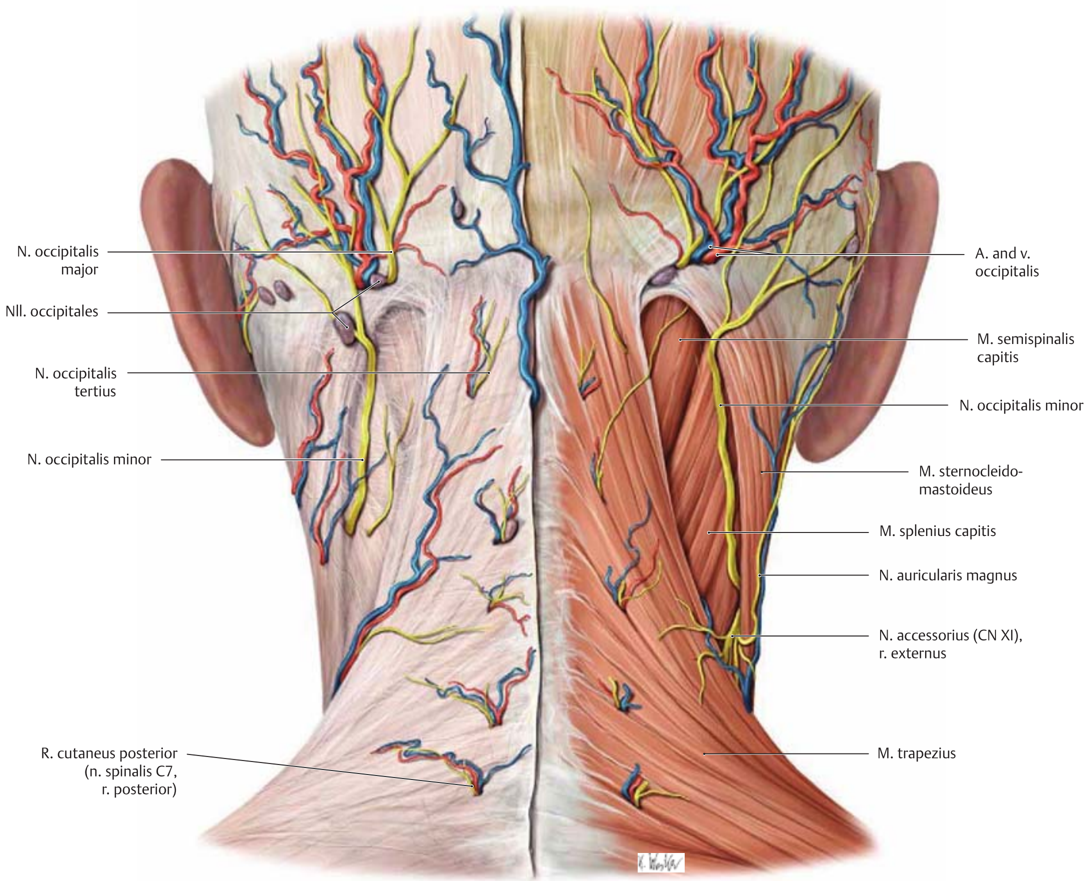
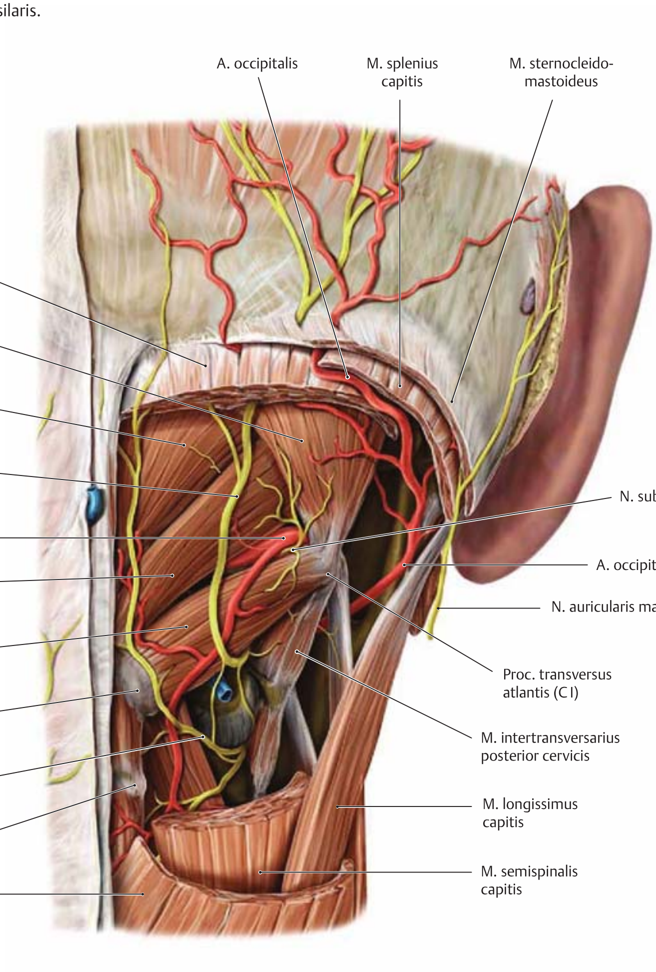
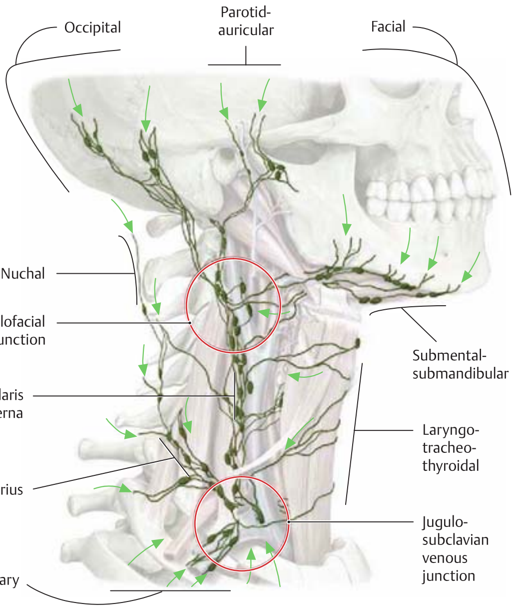


Fig. 37.36 **Suboccipital triangle**
Right side, posterior view. The suboccipital triangle is bounded by the suboccipital muscles (m. rectus capitis posterior major and mm. obliquus capitis superior and inferior) and contains a. vertebralis. The left and right aa. vertebrales pass through the membrana atlantooccipitalis posterior and combine to form a. basilaris.



Lymphatics of the Neck

Fig. 37.37 **Lymphatic drainage regions**
Right lateral view.



Clinical

Tumor metastasis
Lymph from the entire body is channeled to the left and right jugulosubclavian junctions (red circles). Gastric carcinoma may metastasize to the left nll. supraclaviculares, producing an enlarged *sentinel node* (see pp. 73, 231). Systemic lymphomas may also spread to the cervical lymph nodes by this pathway.

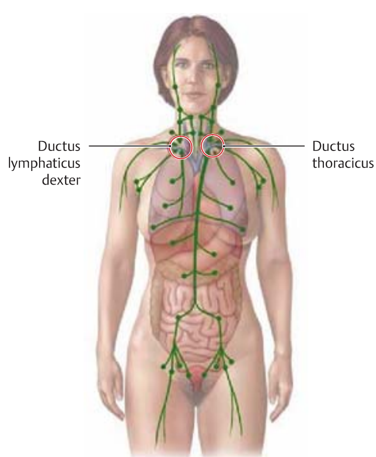


Fig. 37.38 **Superficial cervical lymph nodes**
Right lateral view.

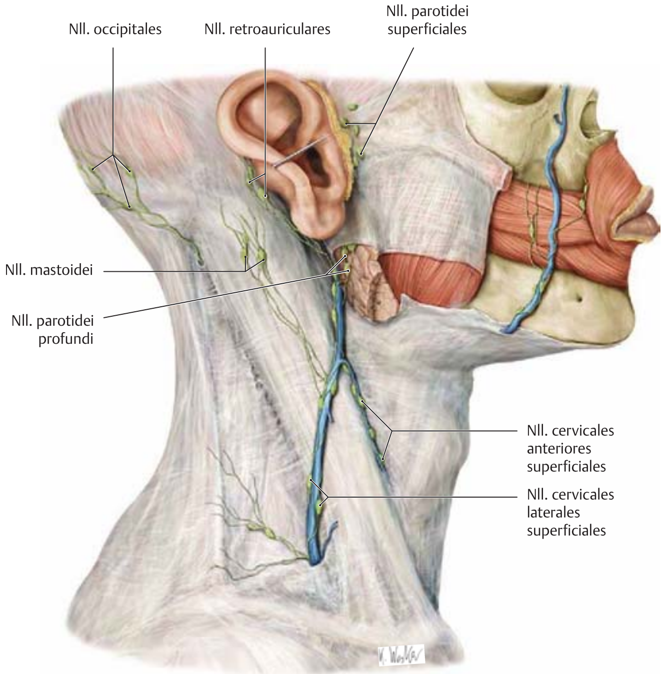


Table 37.13	Superficial cervical lymph nodes
Lymph nodes (l.n.)	**Drainage region**
Nll. retroauriculares	Regio occipitalis
Nll. occipitales	
Nll. mastoidei	
Nll. paratoidei superficiales	Regio parotideo-auricularis
Nll. paratoidei profundi	
Nll. anteriores superficiales	Regio sternocleido-mastoidea
Nll. laterales superficiales	

Fig. 37.39 **Deep cervical lymph nodes**
Right lateral view.

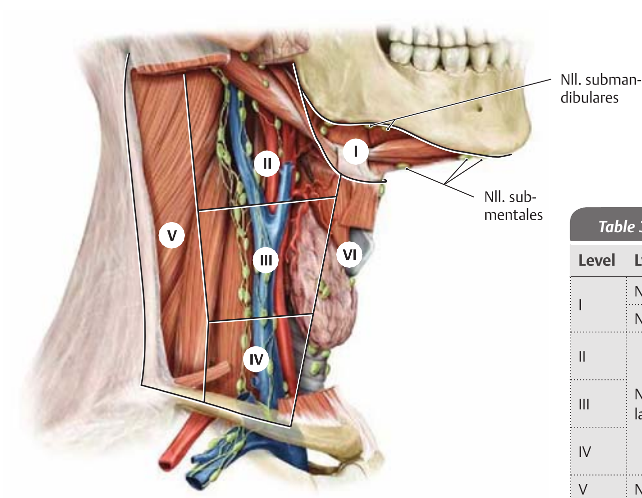
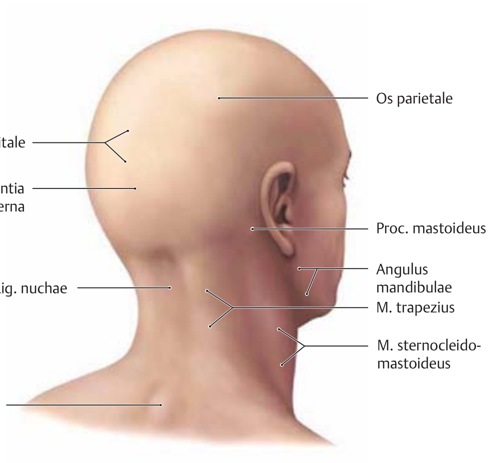


Table 37.14	Deep cervical lymph nodes		
Level	**Lymph nodes (l.n.)**		**Drainage region**
I	Nll. submentales		Face
	Nll. submandibulares		
II	Nll. jugulares laterales	Upper lateral group	Regio nuchalis, laryngo-tracheo-thyroidal region
III		Middle lateral group	
IV		Lower lateral group	
V	Nll. trigoni cervicalis posterioris		Regio nuchalis
VI	Nll. cervicales anteriores		Laryngo-tracheo-thyroidal region

Surface Anatomy

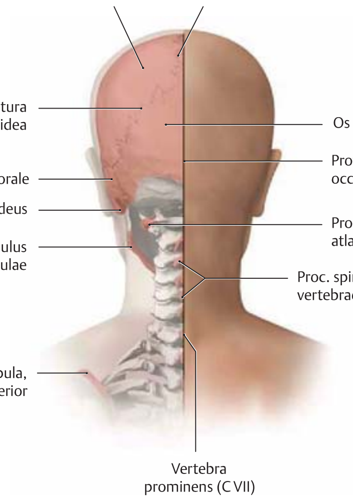
Fig. 38.1 Surface anatomy of the skull and nuchal region



A Surface anatomy. Right posterolateral view.

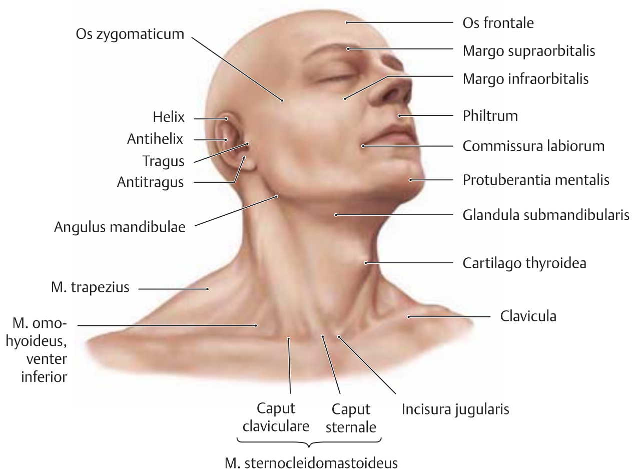
Q1: Injecting a bolus of anesthetic two thirds of the way up the posterior border of m. sternocleidomastoideus would accomplish what task?

Q2: What palpable bony landmark would you use to auscultate the venous blood in the confluence of the sinuses?



B Palpable bony prominences. Posterior view.

Fig. 38.2 **Surface anatomy of the face and neck**

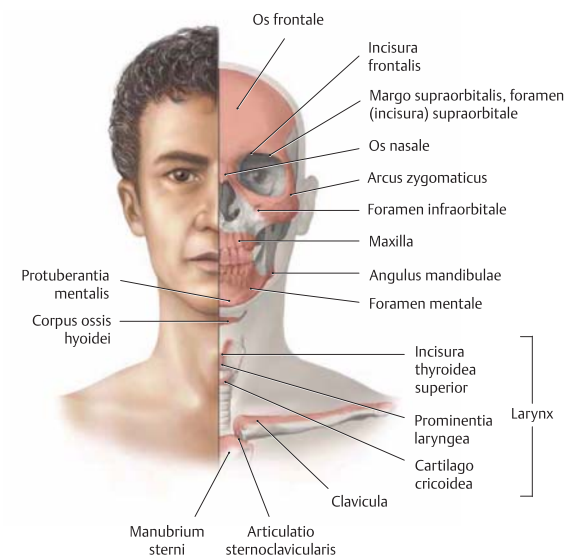


A Surface anatomy. Right anterolateral view.

Q3: What are the boundaries of regio cervicalis lateralis (trigonum cervicale posterius)? Name two structures within this region that supply motor innervation to the muscles of the upper limb.

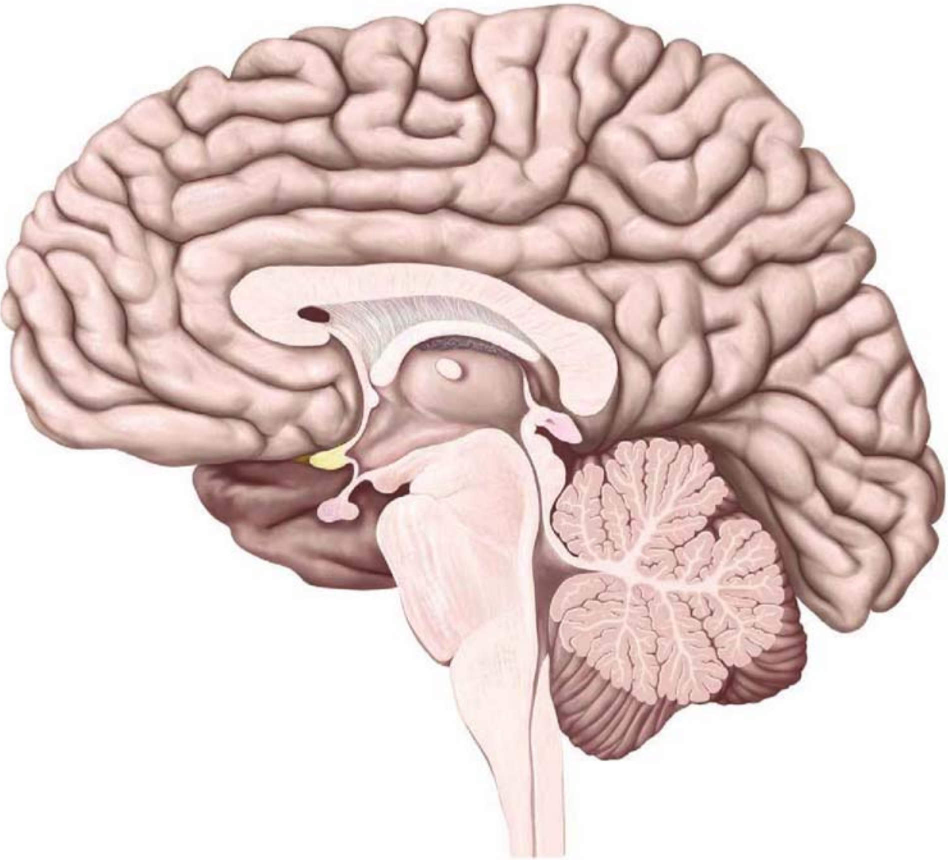
Q4: What are the boundaries of trigonum caroticum? Name one non-vascular component of the vertical neurovascular bundle within vagina carotica located in the trigonum caroticum.

Q5: What is the anatomical structure referred to as the "Adam's apple"?



B Palpable bony prominences. Anterior view.

See answers beginning on p. 626.



Neuroanatomy

39 Brain & Spinal Cord

40 Blood Vessels of the Brain & Spinal Cord

41 Functional Systems

42 Autonomic Nervous System

Nervous System: Overview

Fig. 39.1 Central and peripheral nervous systems

The nervous system is divided into the central (CNS) and peripheral (PNS) nervous systems. The CNS consists of the brain and spinal cord, which comprise a functional unit. The PNS consists of the nerves emerging from the brain and spinal cord (cranial and spinal nerves, respectively).

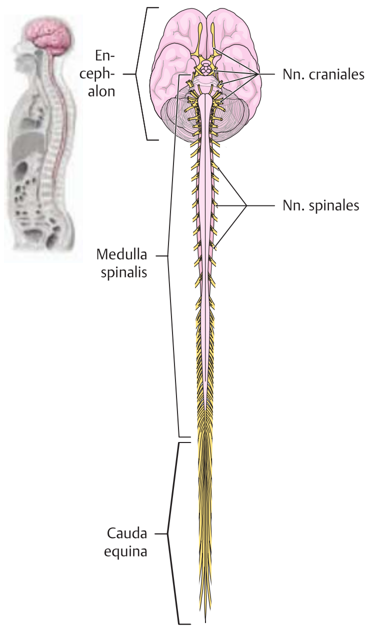


Fig. 39.2 Neurons (nerve cells)

The nervous system is composed of neurons (nerve cells) and supporting neuroglial cells, which vastly outnumber them (10 to 1). Each neuron contains a cell body (soma) with one axon (projecting segment) and one or more dendrites (receptor segments). The release of neurotransmitters at synapses creates an excitatory or inhibitory postsynaptic potential at the target neuron. If this exceeds the depolarization threshold of the neuron, the axon "fires," initiating the release of a transmitter from its presynaptic knob (bouton).

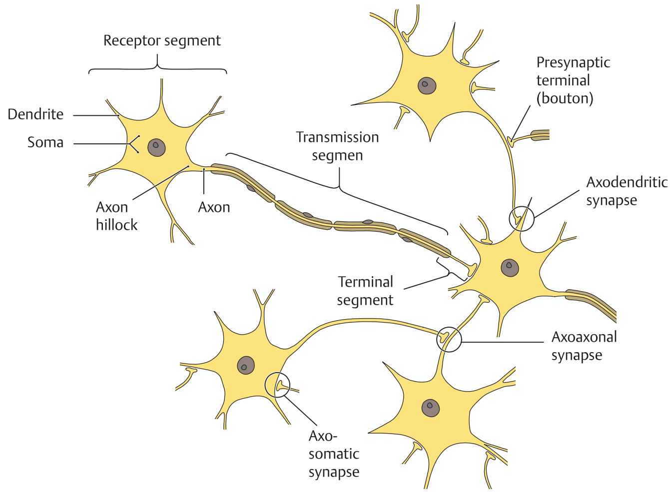


Fig. 39.3 Myelination

Certain glial cells with lipid-rich membranes may myelinate axons (nerve fibers). Myelination electrically insulates axons, thereby increasing impulse conduction speed. In the CNS, one oligodendrocyte myelinates multiple axons; in the PNS, one Schwann cell myelinates one axon.

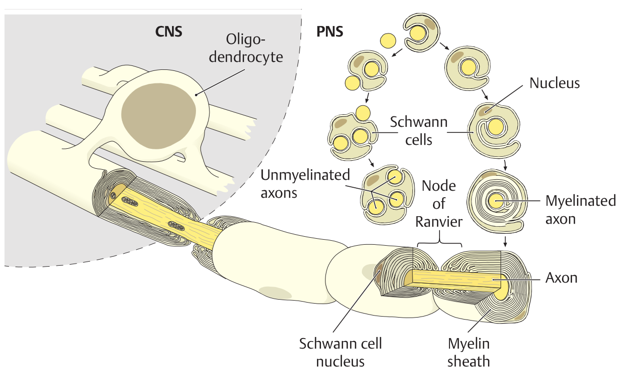
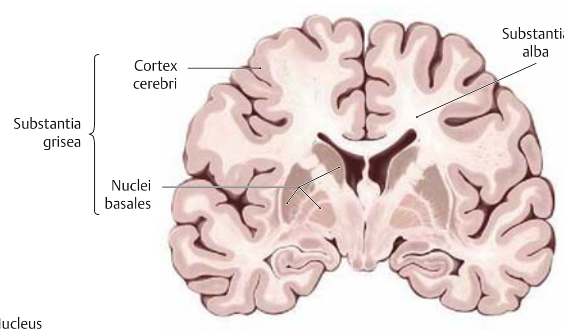
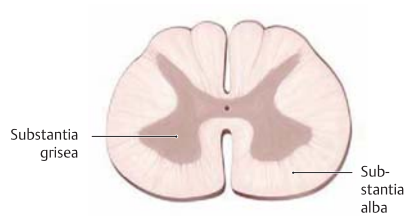


Fig. 39.4 Substantia alba and grisea in CNS

Nerve cell bodies appear gray in gross inspection, whereas nerve cell processes (axons) and their insulating myelin sheaths appear white.



A Coronal section through the brain.



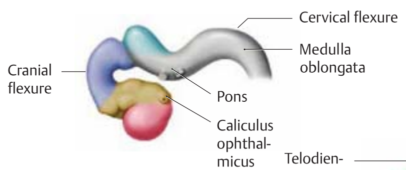
B Transverse section through the spinal cord.

Table 39.1 Development of the brain

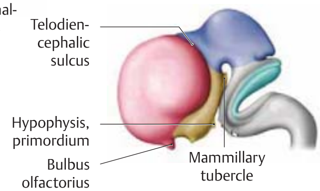
	Primary vesicle	Region		Structure
Neural tube	Pros-encephalon (forebrain)	Telencephalon (cerebrum)		Cortex cerebri, substantia alba and nuclei basales
		Diencephalon		Epithalamus (glandula pinealis), thalamus, subthalamus, and hypothalamus
	Mesencephalon (midbrain)*			Tectum mesencephali, tegmentum, and pedunculi cerebri
	Rhombencephalon (hindbrain)	Metencephalon	Cerebellum	Cortex cerebelli, nuclei cerebelli, and pedunculi cerebri
			Pons*	Nuclei and fiber tracts
		Myelencephalon	Medulla oblongata*	

* The mesencephalon, pons, and medulla oblongata are collectively known as the brainstem.

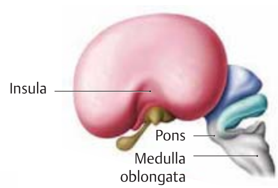
Fig. 39.5 **Embryonic development of the brain**
Left lateral view.



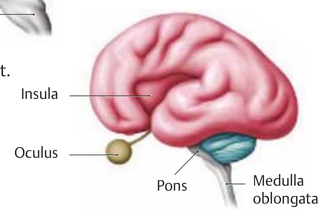
A Start of 2nd month.



B End of 2nd month.

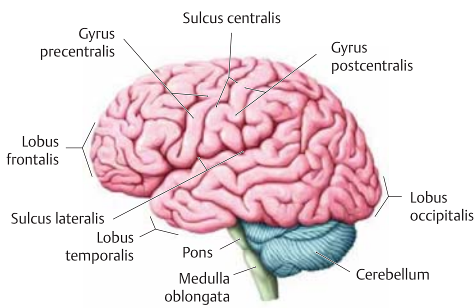


C 3rd month of development.

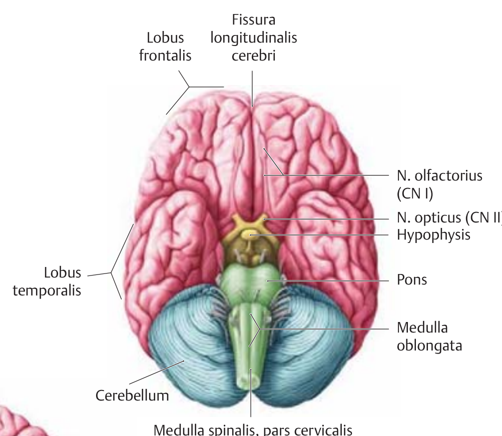


D 7th month.

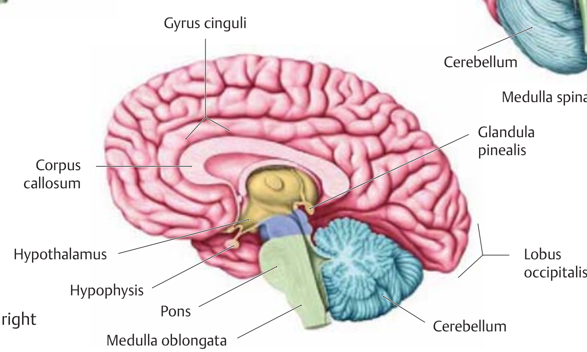
Fig. 39.6 **Adult brain**
See Fig. 39.12 for lobes of the cerebrum. CN = cranial nerve.



A Left lateral view.



B Basal view.



C Midsagittal section showing the right hemisphere.

Telencephalon

Fig. 39.7 Divisions of the telencephalon

Coronal section, anterior view. The telencephalon is divided into cortex cerebri, substantia alba, and nuclei basales. The cortex cerebri is further divided into the allocortex and isocortex (neocortex).

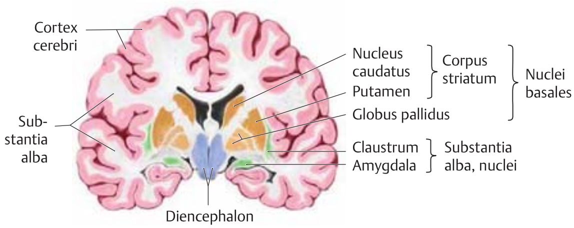


Fig. 39.9 Nuclei basales

Transverse section, superior view. The nuclei basales are an essential component of the motor system (see p. 615).

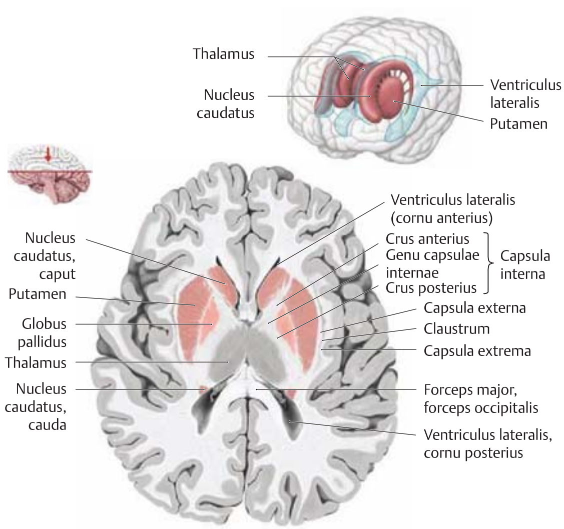
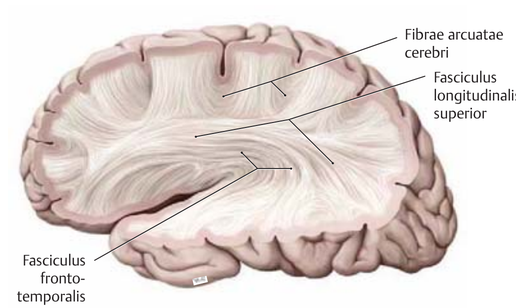
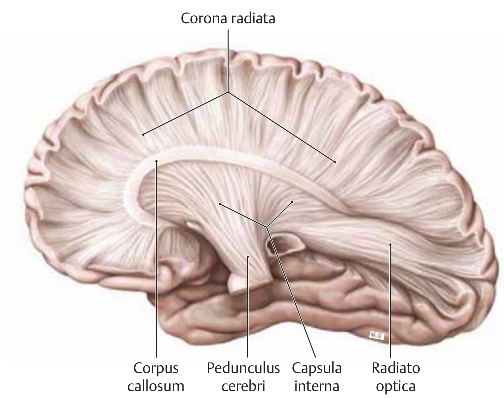


Fig. 39.8 Substantia alba

A special preparation technique was used to show the fiber structure of the superficial layer of substantia alba.



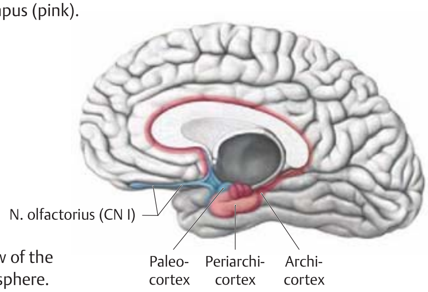
A Lateral view of left hemisphere.



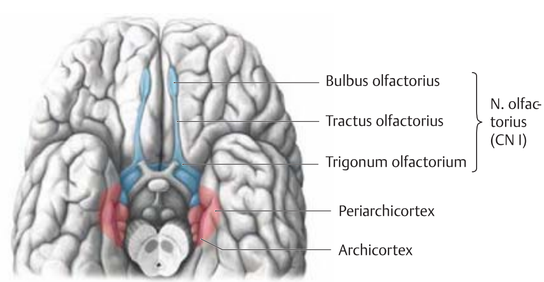
B Medial view of right hemisphere.

Fig. 39.10 Allocortex

The three-layered allocortex consists of the olfactory cortex (blue) and the hippocampus (pink).



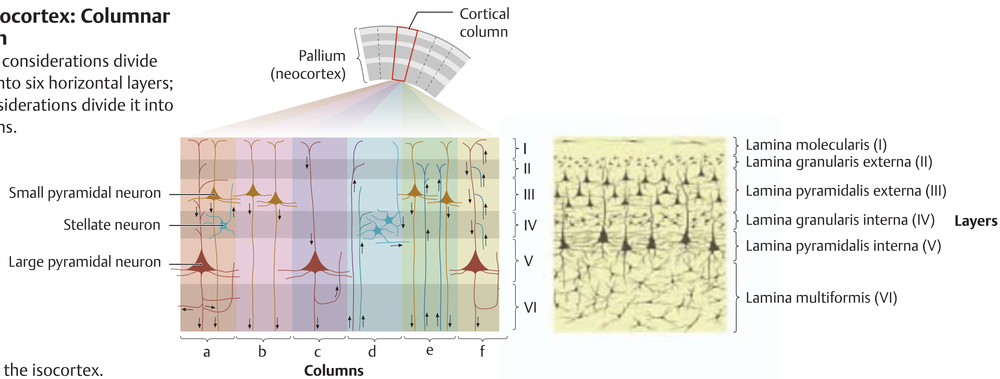
A Medial view of the right hemisphere.



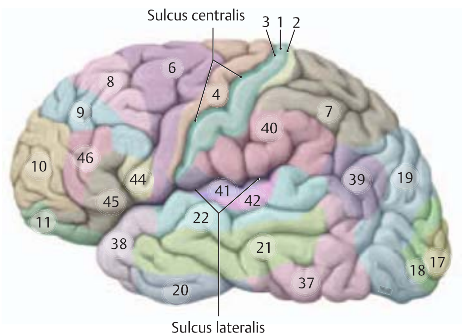
B Basal view.

Fig. 39.11 Isocortex: Columnar organization

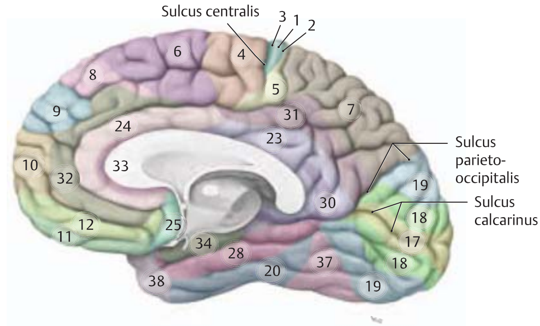
Morphological considerations divide the isocortex into six horizontal layers; functional considerations divide it into cortical columns.



A Histology of the isocortex.



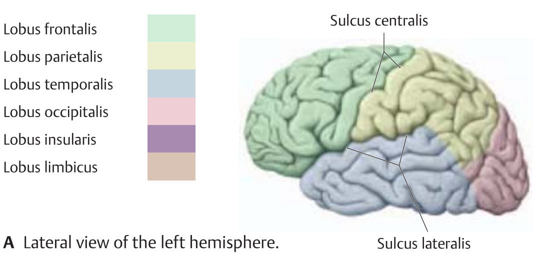
B Brodmann (cortical) areas, lateral view of the left cerebral hemisphere.



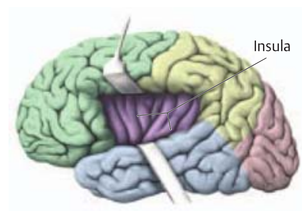
C Brodmann (cortical) areas, medial view of the right cerebral hemisphere.

Fig. 39.12 Lobes in the cerebral hemispheres

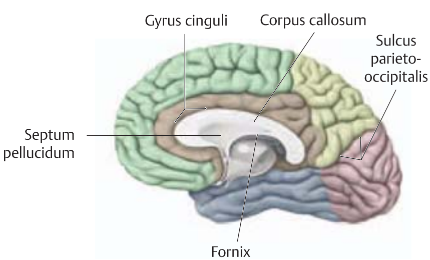
The isocortex also may be functionally divided into association areas (lobes).



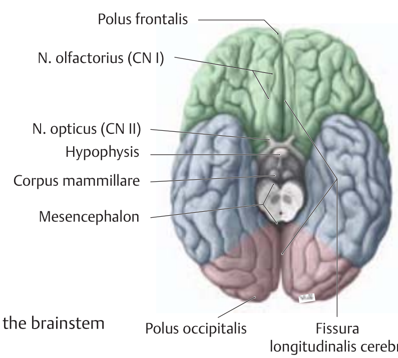
A Lateral view of the left hemisphere.



B Lateral view of the retracted left cerebral hemisphere.

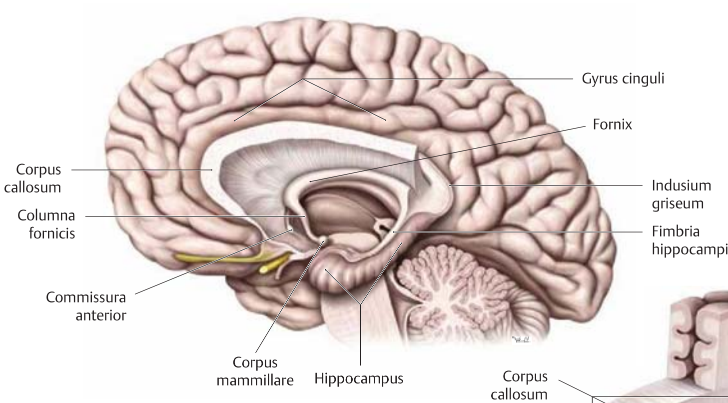


C Medial view of the right hemisphere.



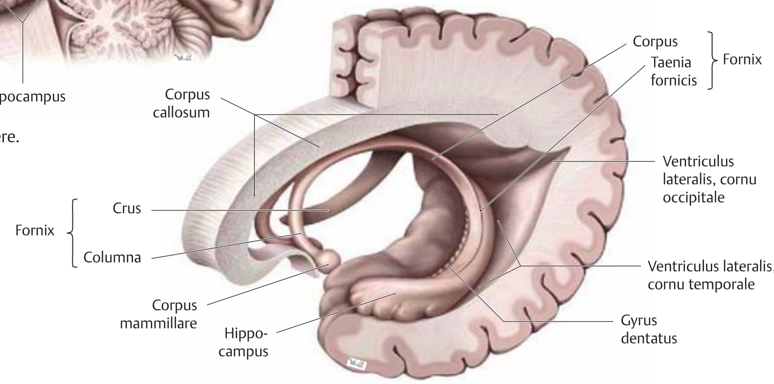
D Basal view with the brainstem removed.

Telencephalon & Diencephalon



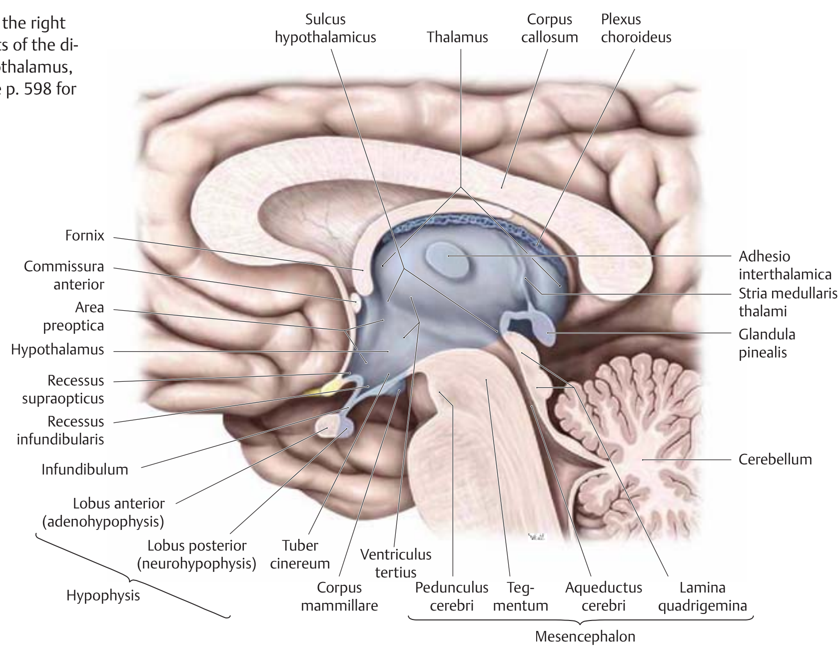
A Lateral view of the dissected left hemisphere.

Fig. 39.13 **Hippocampal formation**
The hippocampus, fornix, and amygdala are the major components of the limbic system (see p. 621).



B Left anterosuperior view.

Fig. 39.14 **Diencephalon**
Midsagittal section, medial view of the right hemisphere. The major components of the diencephalon are the thalamus, hypothalamus, and hypophysis (anterior lobe). See p. 598 for the extracted diencephalon.



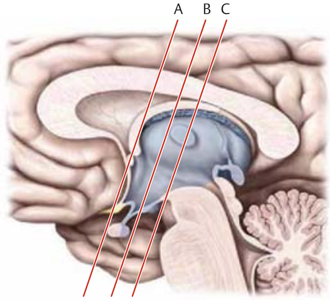


Table 39.2 Structures of the diencephalon

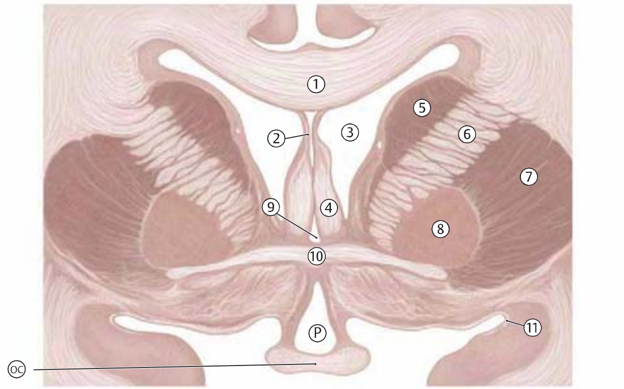
Ⓟ	Recessus preopticus	
ⓄⒸ	Chiasma opticum	
3V	Ventriculus tertius	
ⓄⓉ	Tractus opticus	
In	Infundibulum	
Ⓣ	Thalamus (with nuclei thalamici):	
	Ⓡ	Nucleus reticularis
	Ⓔ	Lamina medullaris externa
	Ⓥ	Nuclei ventrolaterales
	Ⓘ	Lamina medullaris interna
	Ⓜ	Nuclei mediales
	Ⓐ	Nuclei anteriores
	Ⓟ	Nuclei paraventriculares
Ⓢ	Nucleus subthalamicus	
SN*	Substantia nigra	
MF	Fasciculus mammillothalamicus	
MB	Corpus mammillaria	

*Actually a structure of the mesencephalon.

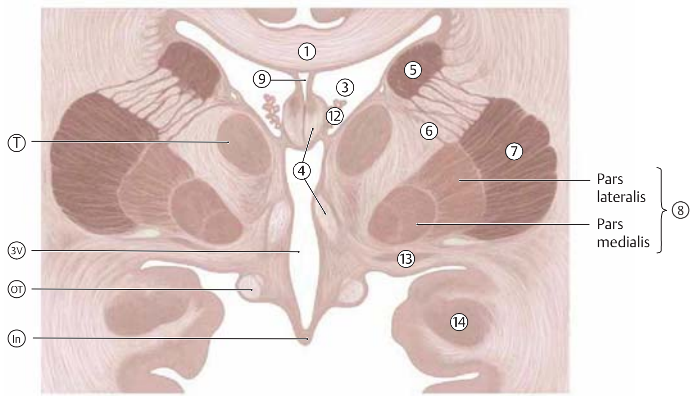
Table 39.3 Structures of the telencephalon

①	Corpus callosum
②	Septum pellucidum
③	Ventriculus lateralis
④	Fornix
⑤	Nucleus caudatus
⑥	Capsula interna
⑦	Putamen
⑧	Globus pallidus
⑨	Cavum septi pellucidi
⑩	Commissura anterior
⑪	Stria olfactoria lateralis
⑫	Plexus choroideus
⑬	Basal ganglia (nuclei basales)
⑭	Amygdala
⑮	Hippocampus

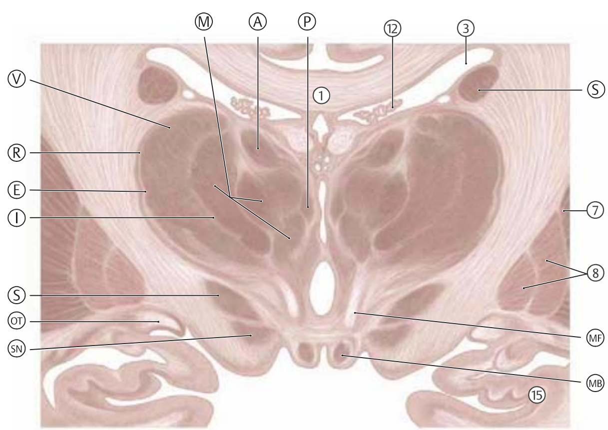
Fig. 39.15 **Telencephalon and diencephalon: Internal structure**
Coronal section.



A Level of chiasma opticum.



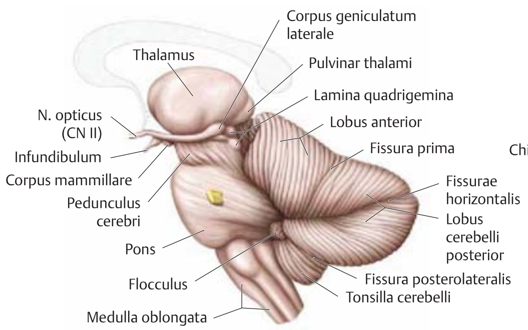
B Level of the tuber cinereum.



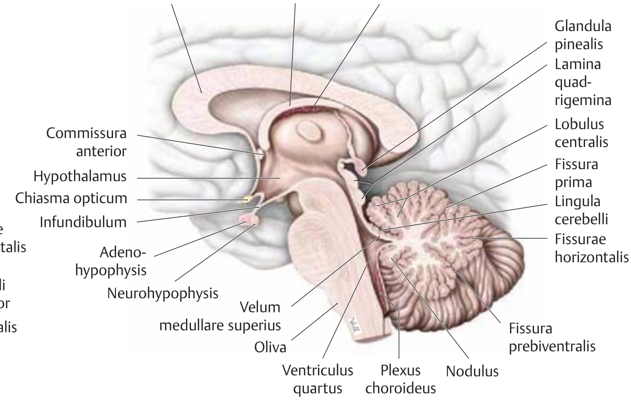
C Level of corpora mamillaria.

Diencephalon, Brainstem & Cerebellum

Fig. 39.16 **Diencephalon, brainstem, and cerebellum**
Left lateral view.

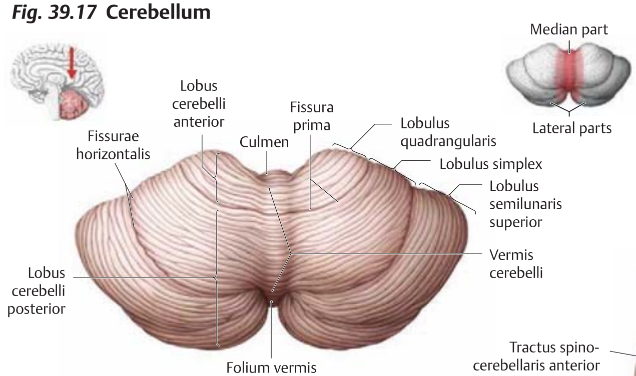


A Isolated structures.

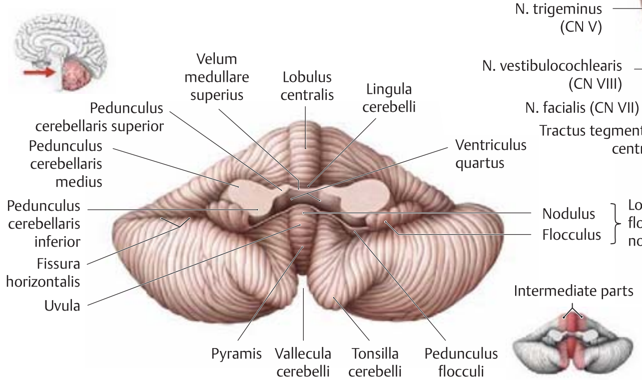


B Midsagittal section.

Fig. 39.17 **Cerebellum**



A Superior view.



B Anterior view.

Fig. 39.18 **Pedunculi cerebelleres**
Tracts of afferent (sensory) or efferent (motor) axons enter or leave the cerebellum through cerebellar peduncles. Afferent axons originate in the spinal cord, vestibular organs, inferior olive, and pons. Efferent axons originate in the cerebellar nuclei.

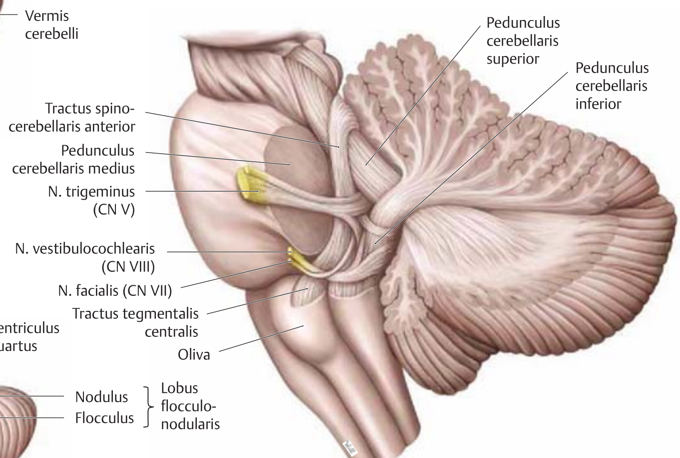
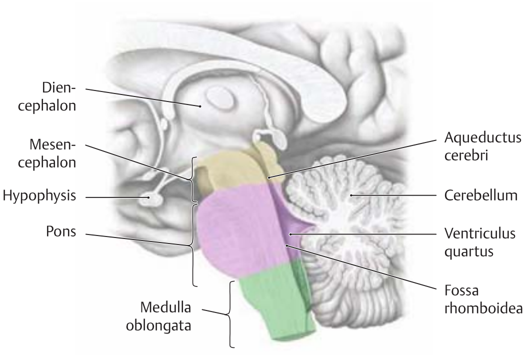
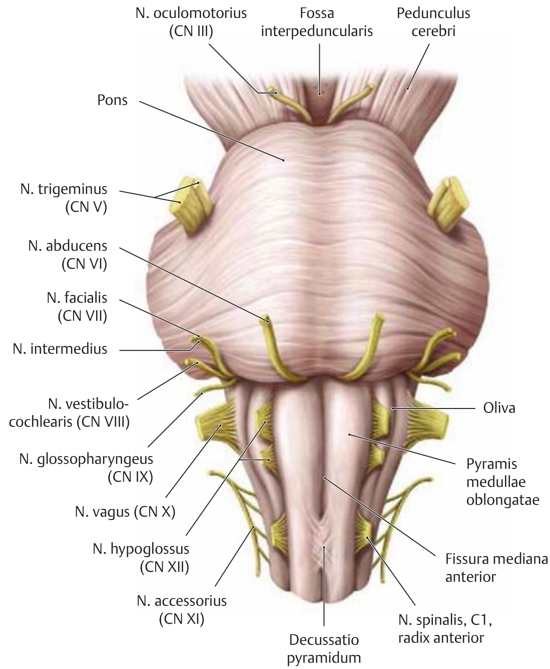


Fig. 39.19 **Brainstem**

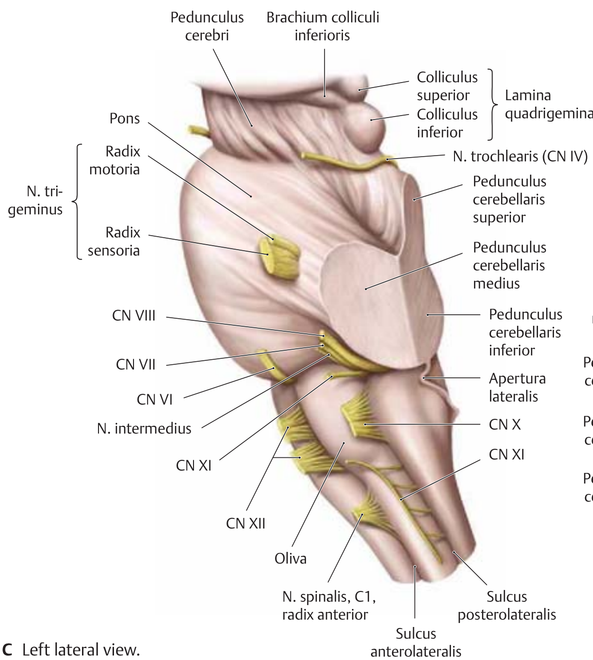
The brainstem is the site of emergence and entry of the 10 pairs of true cranial nerves (CN III–XII). See p. 470 for an overview of the cranial nerves and their nuclei.



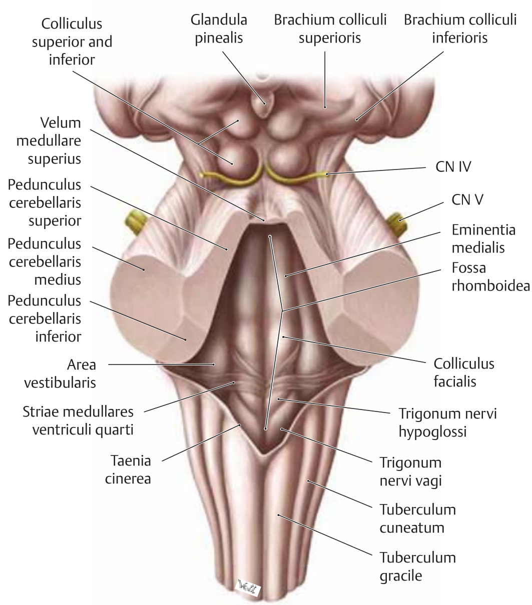
A Levels of the brainstem.



B Anterior view.



C Left lateral view.

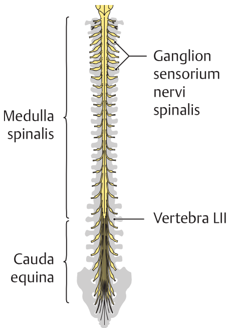


D Posterior view.

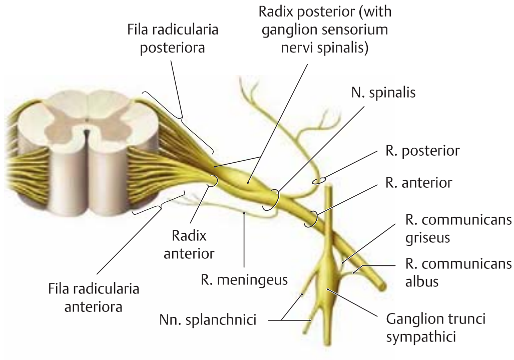
Medulla Spinalis

Fig. 39.20 Medulla spinalis and segments

Medulla spinalis consists of 31 segments innervating a specific area in the trunk or limbs (see Fig. 39.22). Afferent (sensory) posterior rootlets and efferent (motor) anterior rootlets form the radix posterior and anterior, respectively. The two radicis fuse to form a mixed n. spinalis, which then divides into various branches.



A Spinal cord, posterior view.



B Spinal cord segment, anterior view.

Fig. 39.21 Medulla spinalis in situ

Posterior view with vertebral canal windowed.

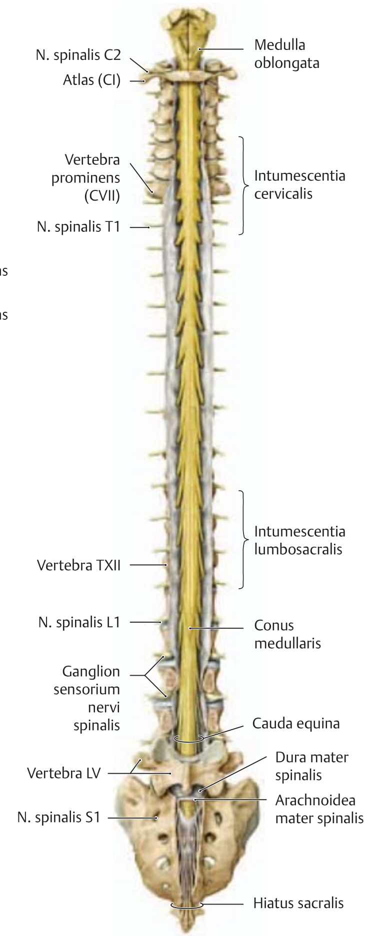
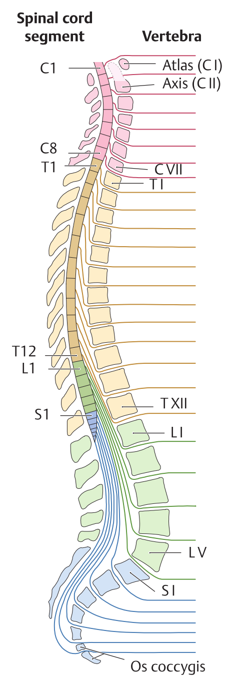
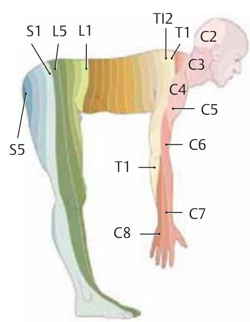


Fig. 39.22 Segmental innervation of medulla spinalis lesions

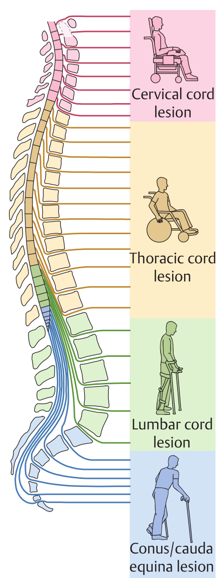
Medulla spinalis is divided into four major regions: cervical, thoracic, lumbar, and sacral. Spinal cord segments are numbered by the exit points of their associated spinal nerves. (*Note:* This does not necessarily correlate numerically with the nearest skeletal element.)



A Spinal cord segments.



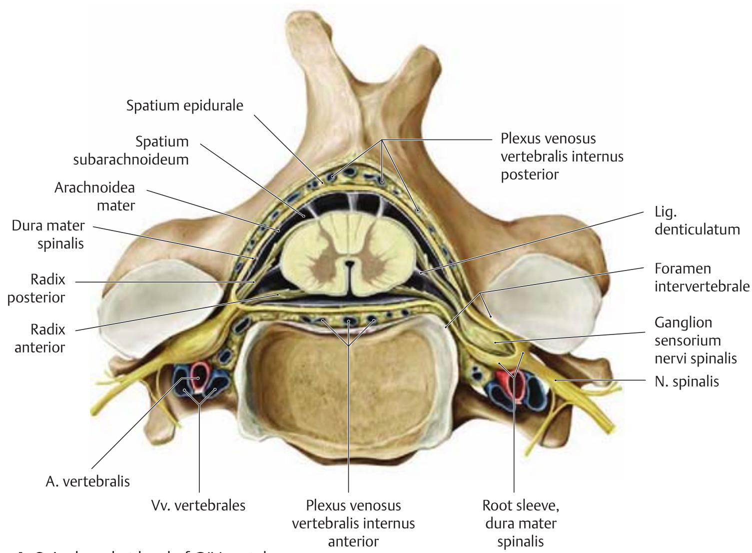
B Dermatomes. Each spinal cord segment innervates a particular skin area (dermatome).



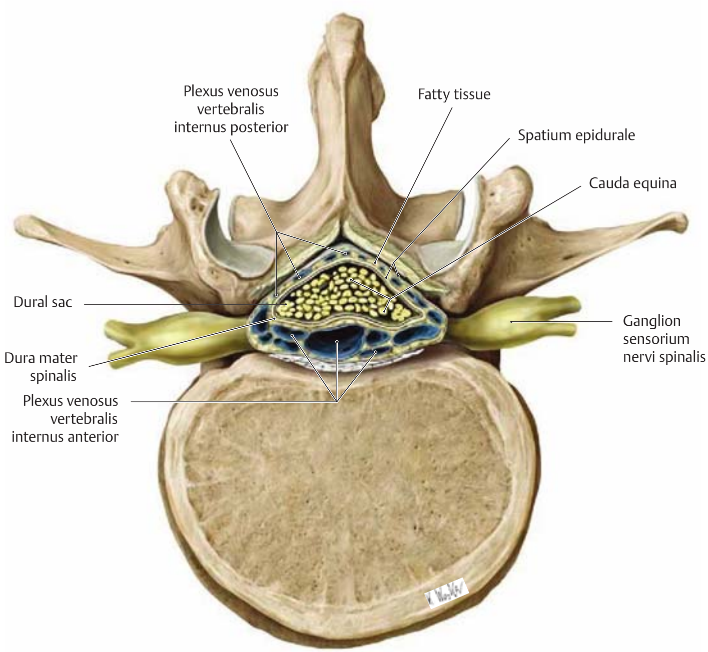
C Spinal cord lesions.

Fig. 39.23 Spinal cord in situ: Transverse section

Superior view.



A Spinal cord at level of C IV vertebra.

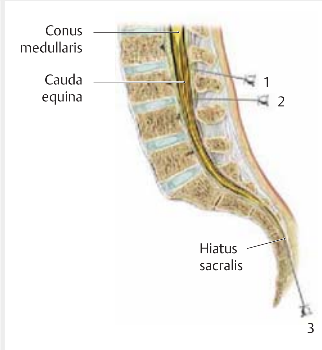


B Cauda equina at level of L II vertebra.

Clinical

Lumbar puncture

A needle introduced into the dural sac (lumbar cistern) generally slips past the spinal nerve roots without injuring the spinal cord. Cerebrospinal fluid (CSF) samples are therefore taken between the L III and L IV vertebrae (2), once the patient has leaned forward to separate the spinous processes of the lumbar spine.

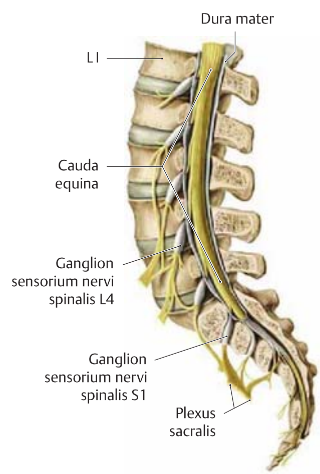


Anesthesia

Lumbar anesthesia may be administered in a similar fashion (2). Epidural anesthesia is administered by placing a catheter in the epidural space without penetrating the dural sac (1). This may also be done by passing a needle through hiatus sacralis (3).

Fig. 39.24 Cauda equina

In adults, the spinal cord ends at approximately the level of L I. Below this, ventral and dorsal roots course through canalis vertebralis, uniting in the foramen intervertebrale to form the spinal nerve (see p. 36).

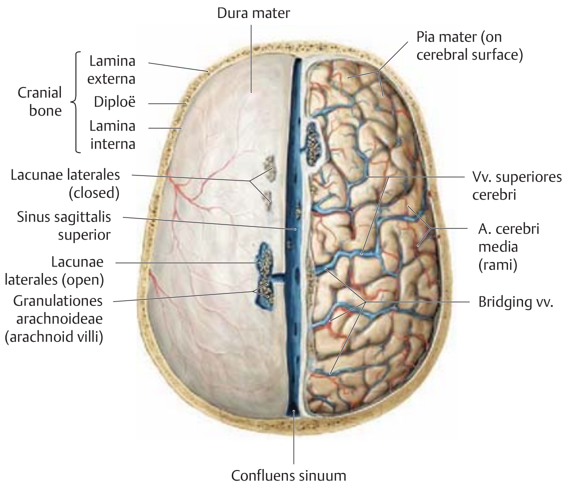


Meninges

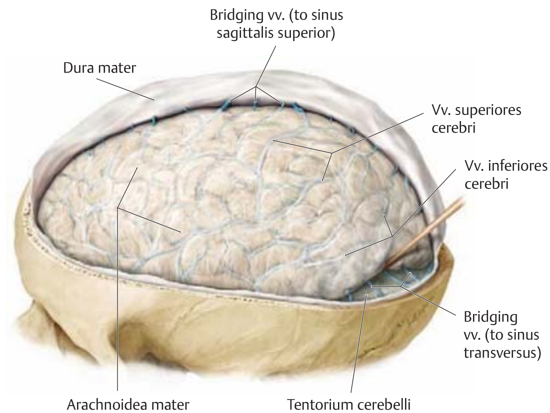
The brain and spinal cord are covered by membranes called meninges. The meninges are composed of three layers: dura mater (dura), arachnoidea mater, and pia mater.

The subarachnoid space, located between the arachnoid and pia, contains cerebrospinal fluid (CSF, see p. 604). See p. 601 for the coverings of the spinal cord.

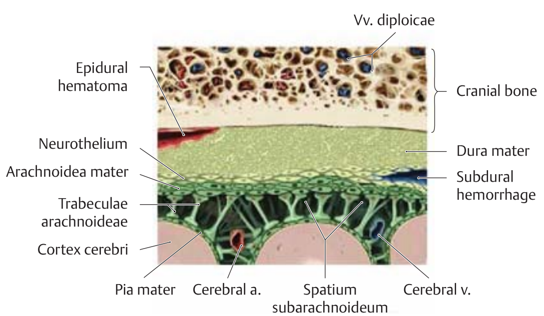
Fig. 39.25 **Meninges**
See p. 606 for the veins of the brain.



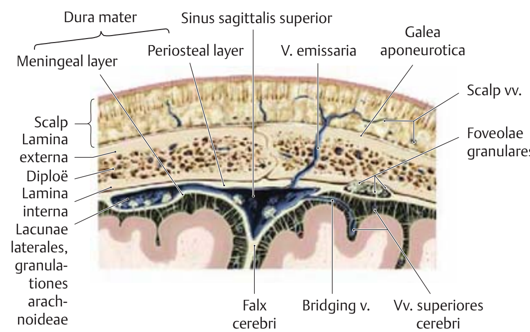
A Superior view. Left side: Dura mater (outer layer). Right side: Pia mater (inner layer). Granulationes arachnoidea (protrusions of the arachnoid) are sites for reabsorption of CSF.



B Arachnoidea mater, left anterior oblique view.



C Layers of the meninges, coronal section, anterior view.

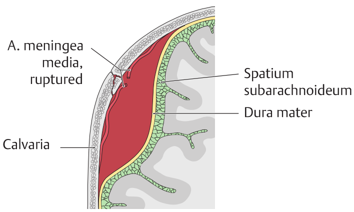


D Dura mater and calvarium, coronal section, anterior view.

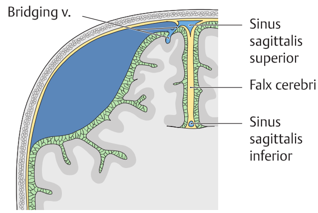
Clinical

Extracerebral hemorrhages

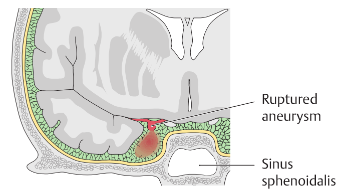
Bleeding between the bony calvarium and the soft tissue of the brain (extracerebral hemorrhage) exerts pressure on the brain. A rise of intracranial pressure may damage brain tissue both at the bleeding site and in more remote brain areas. Three types of intracranial hemorrhage are distinguished based on the relationship to the dura mater. See p. 608 for the arteries of the brain.



A Epidural hematoma (above the dura).



B Subdural hematoma (below the dura).



C Subarachnoid hemorrhage.

Fig. 39.26 **Dural septa**

Left anterior oblique view. The major dural reflections are the falx cerebri, tentorium cerebelli, and falx cerebelli (not shown). The dural septa separate the regions of the brain from each other.

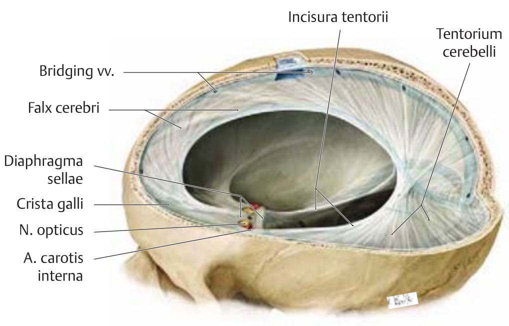


Fig. 39.27 **Innervation of the dura mater**

Superior view. *Removed:* Tentorium cerebelli (right side).

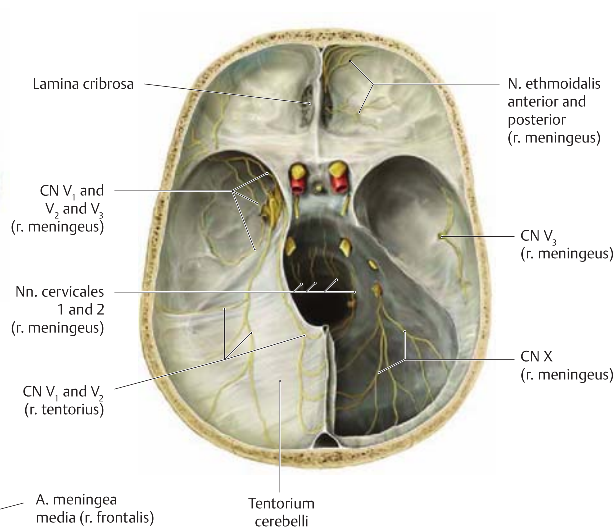


Fig. 39.28 **Arteries of the dura mater**

Midsagittal section, left lateral view. See p. 608 for the arteries of the brain.

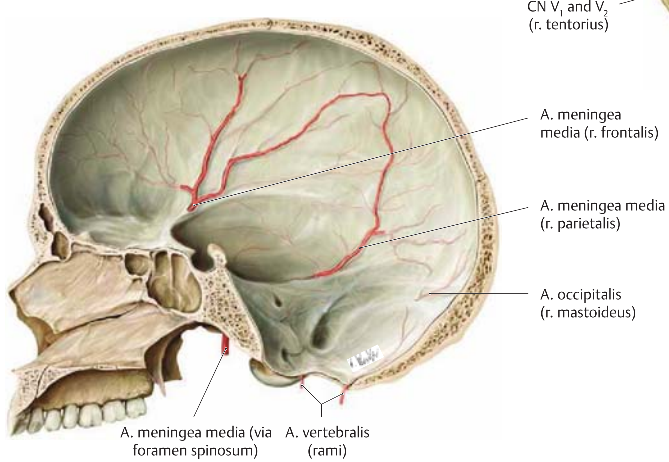


Fig. 39.29 **Circulation of liquor cerebrospinalis (cerebrospinal fluid, CSF)**
The brain and spinal cord are suspended in CSF. Produced in plexus choroideus, CSF occupies the spatium subarachnoideum and ventriculi of the brain.

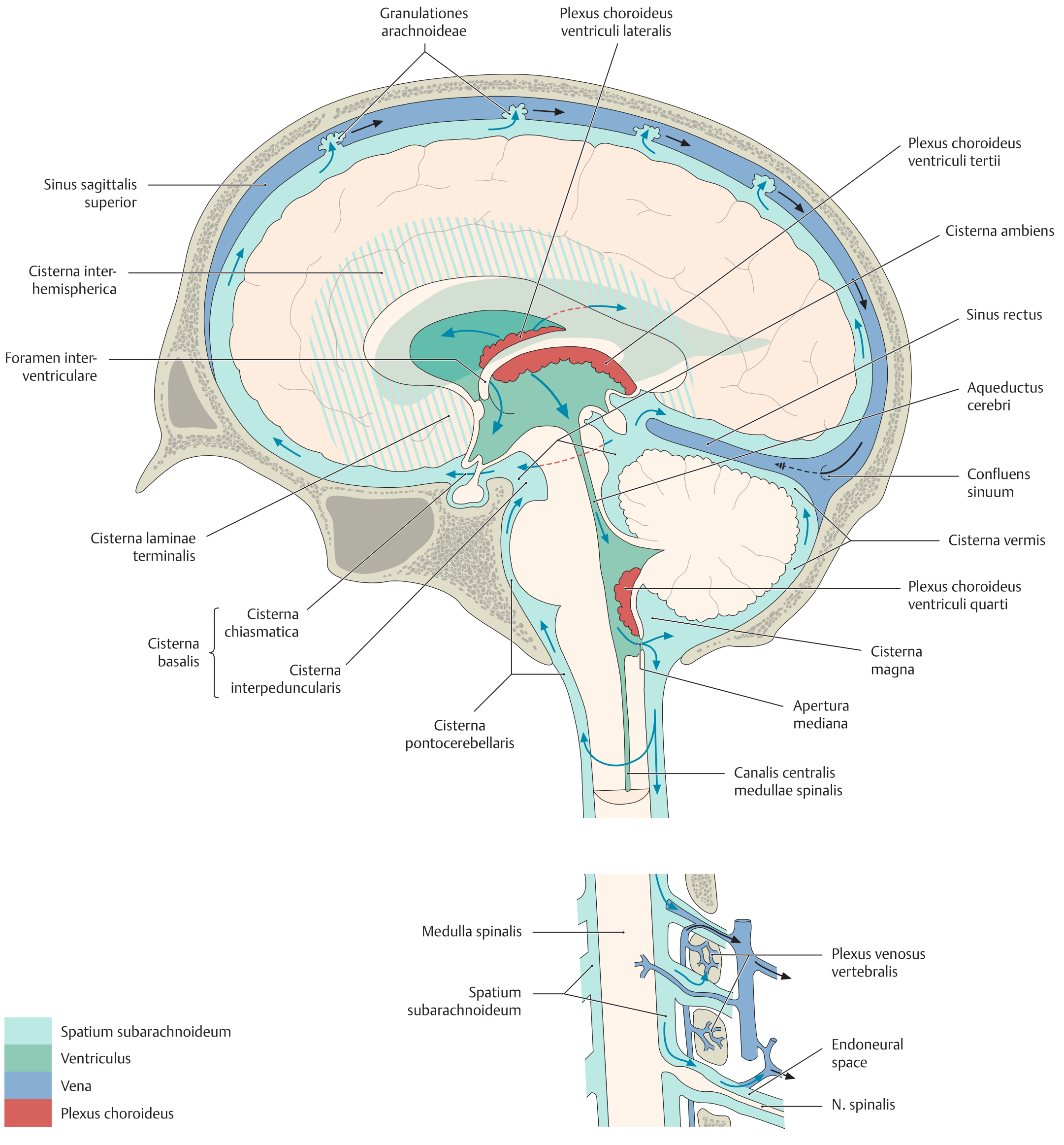
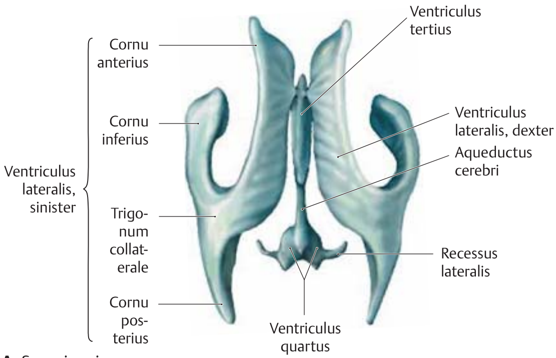
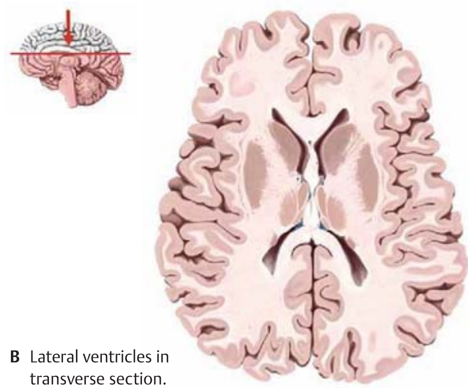


Fig. 39.30 Ventricular system

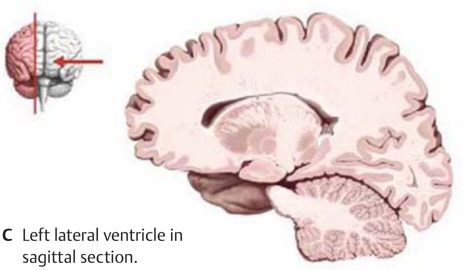
The ventricular system is a continuation of the central spinal canal into the brain. Cast specimens are used to demonstrate the connections between the four ventricular cavities.



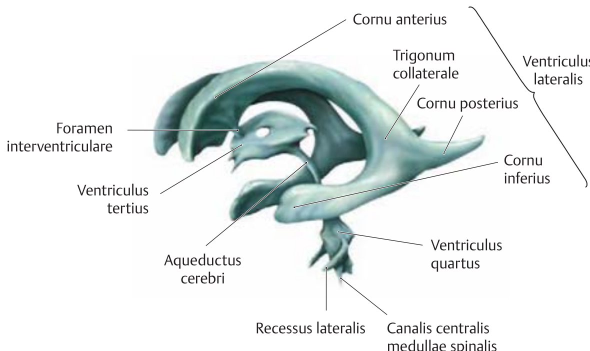
A Superior view.



B Lateral ventricles in transverse section.



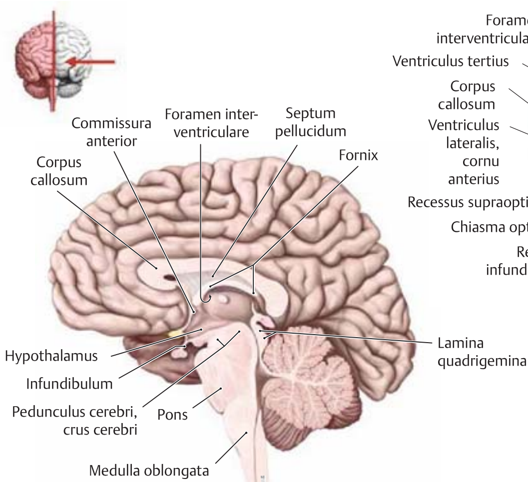
C Left lateral ventricle in sagittal section.



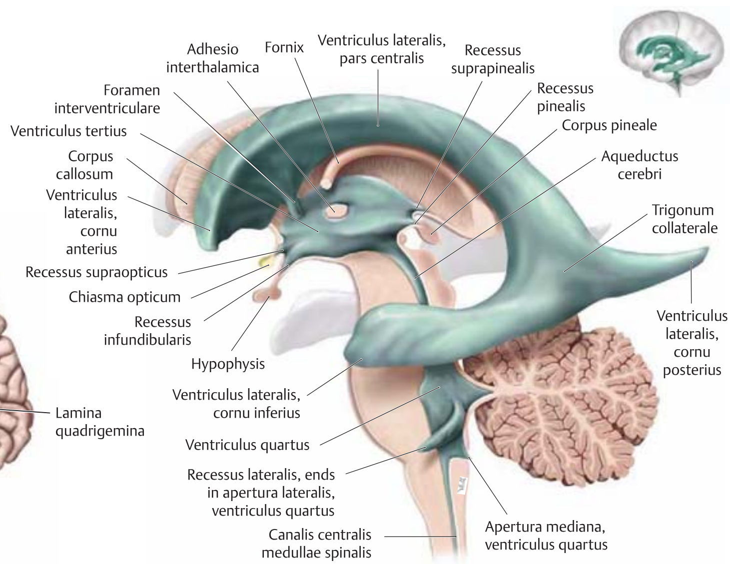
D Left lateral view.

Fig. 39.31 Ventricular system in situ

Left lateral view.



A 3rd and 4th ventricles in the midsagittal section.



B Ventricular system with neighboring structures.

Sinus Durae Matris & Veins of the Brain

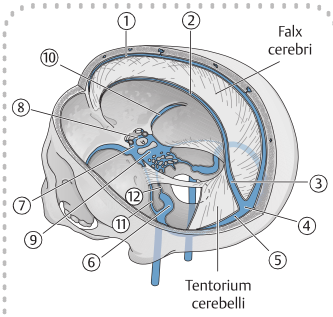


Table 40.1 Principal sinus durae matris

	Upper group		Lower group
①	Sinus sagittalis superior	⑦	Sinus cavernosus
②	Sinus sagittalis inferior	⑧	Sinus intercavernosus anterior
③	Sinus rectus	⑨	Sinus intercavernosus posterior
④	Confluens sinuum	⑩	Sinus sphenoparietalis
⑤	Sinus transversus	⑪	Sinus petrosus superior
⑥	Sinus sigmoideus	⑫	Sinus petrosus inferior

The sinus occipitalis is also included in the upper group (see Fig. 40.2).

Fig. 40.1 **Confluence sinuum**
Posterior view.

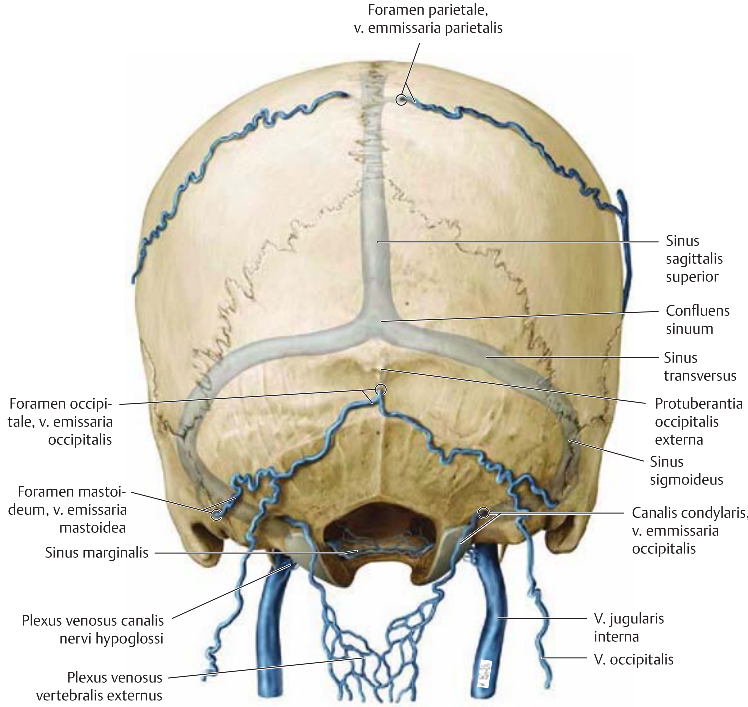
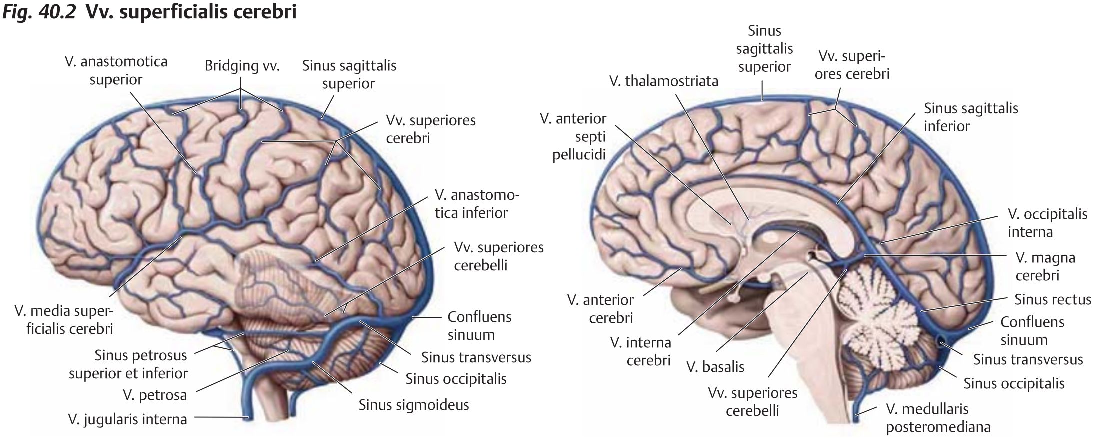


Fig. 40.2 **Vv. superficialis cerebri**



A Lateral view of the left hemisphere.

Fig. 40.3 Basal cerebral venous system
Basal view.

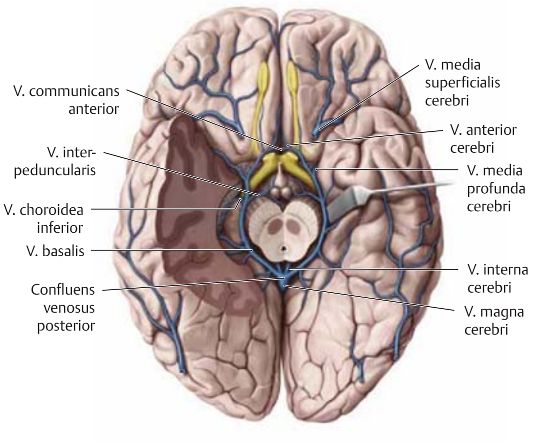


Fig. 40.4 Veins of the brainstem
Basal view.

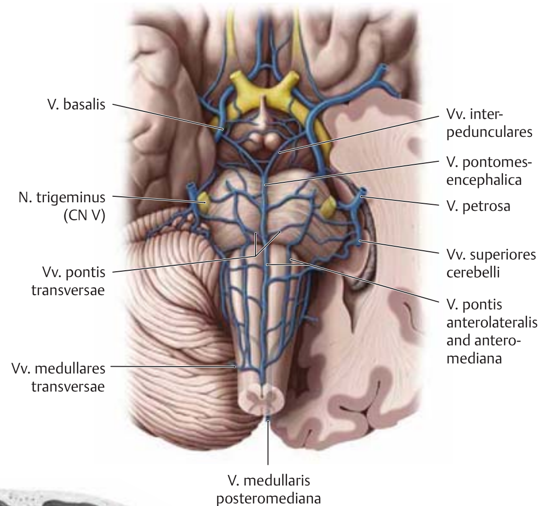
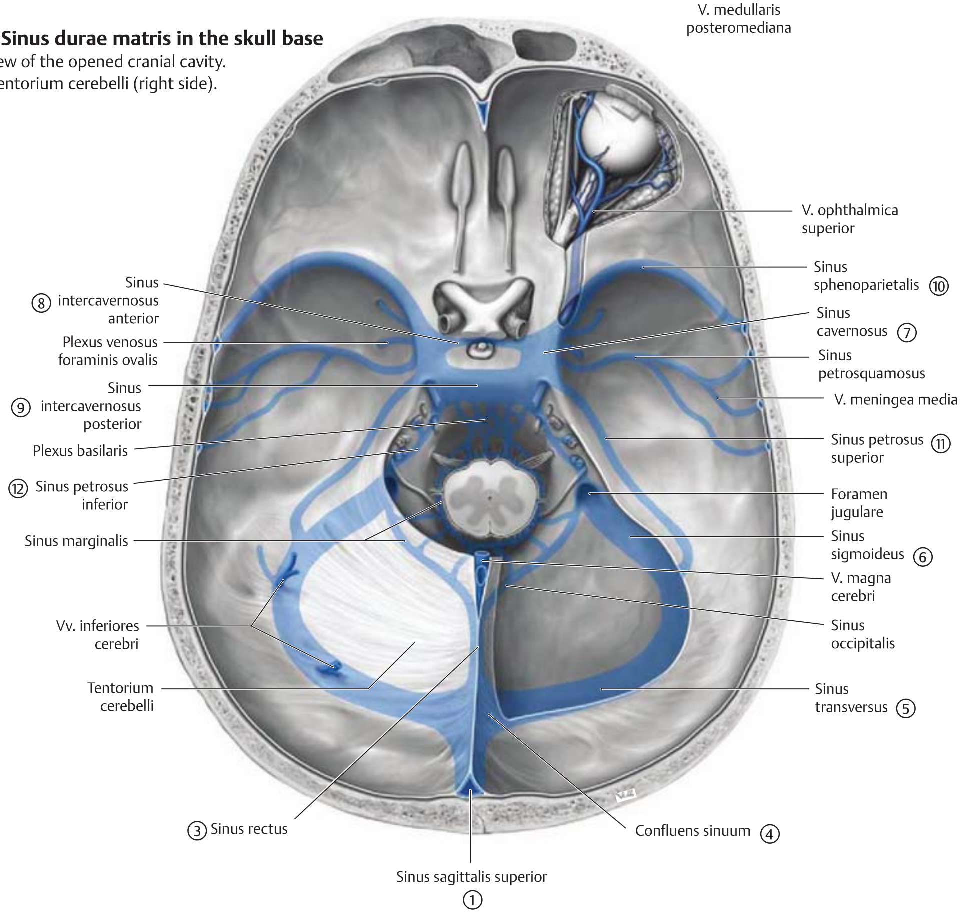


Fig. 40.5 Sinus durae matris in the skull base
Superior view of the opened cranial cavity.
Removed: Tentorium cerebelli (right side).



Arteries of the Brain

Fig. 40.6 **A. carotis interna**
Left lateral view. See p. 490 for details of the a. carotis interna.

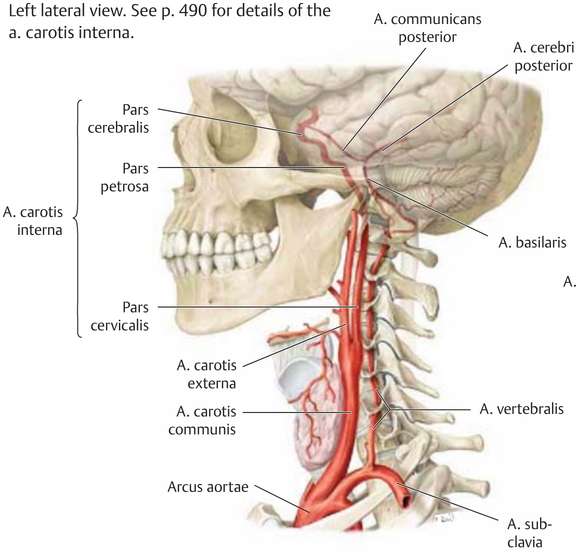


Fig. 40.7 **Arteries of the brainstem and cerebellum**
Left lateral view.

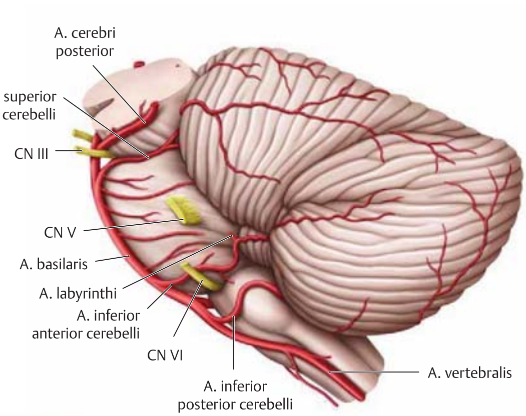


Fig. 40.8 **Arteries of the brain**
Basal (inferior) view.

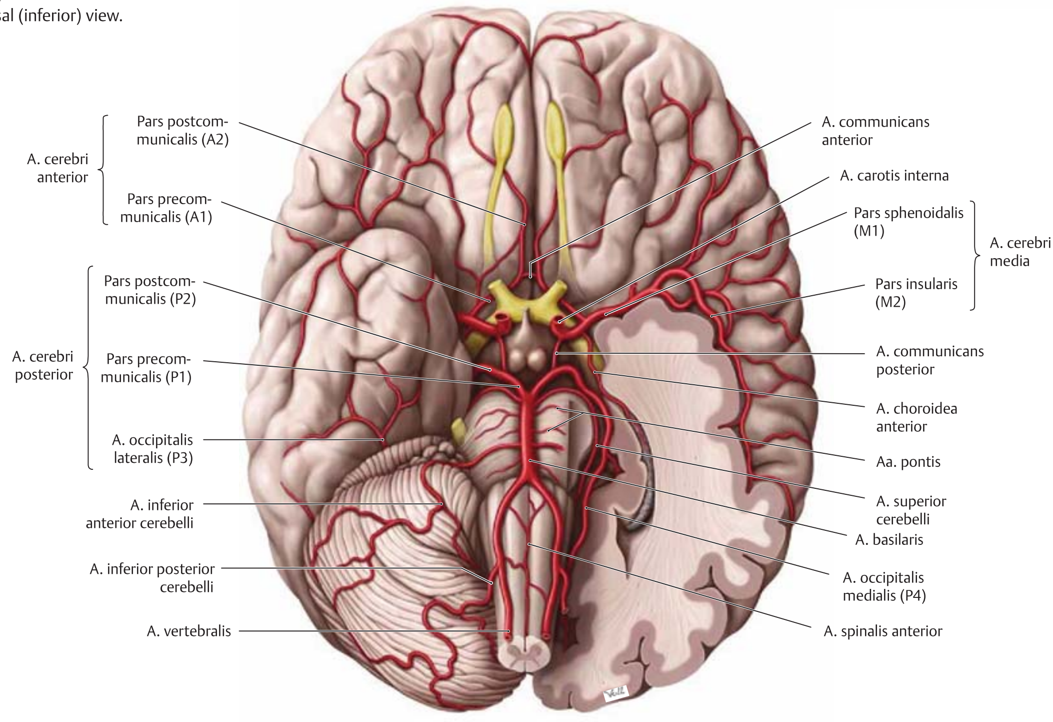
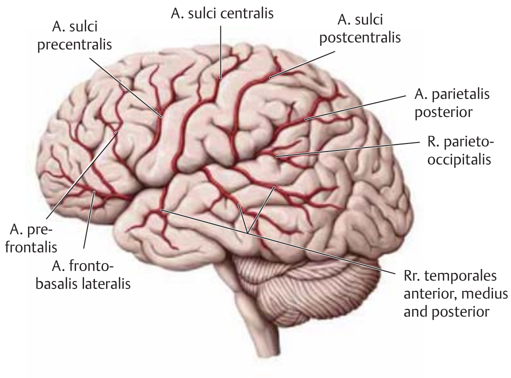
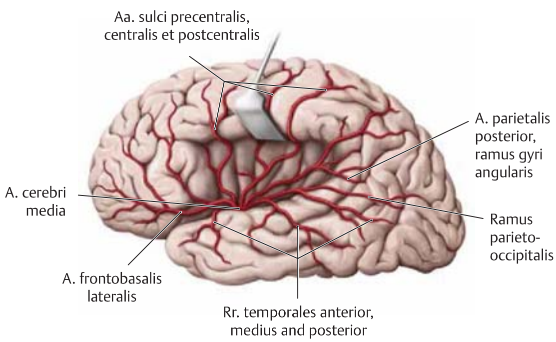


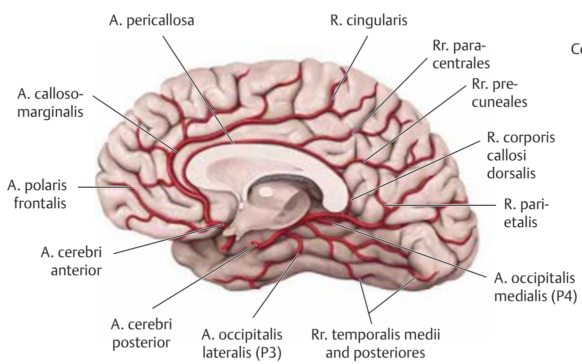
Fig. 40.9 **Cerebral arteries**



A A. cerebri media. Lateral view of the left hemisphere.



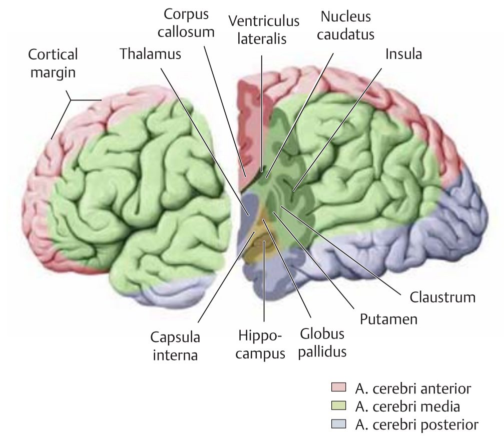
B A. cerebri media. Left lateral view with the lateral sulcus retracted.



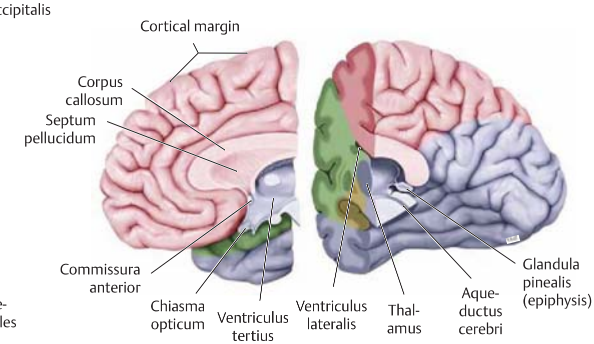
C Aa. cerebri anterior and posterior. Medial view of the right hemisphere.

Fig. 40.10 **Cerebral arteries: Distribution areas**

The central gray and white matter have a complex blood supply (yellow) that includes a. choroidea anterior.



A Lateral view of the left hemisphere.

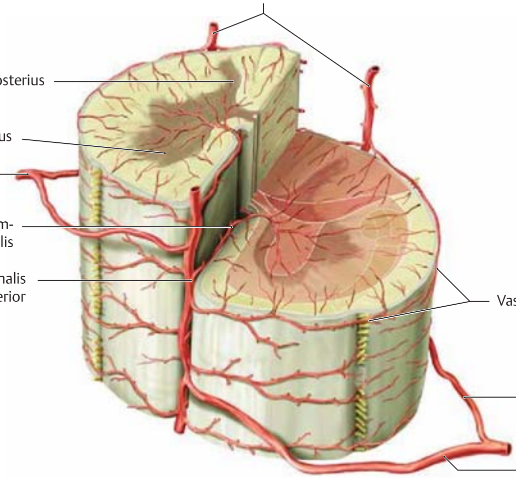


B Medial view of the right hemisphere.

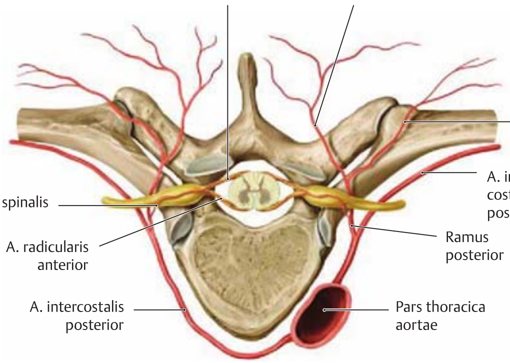
Arteries & Veins of Medulla Spinalis

Like medulla spinalis itself, the arteries and veins of medulla spinalis consist of multiple horizontal systems (blood vessels of the spinal cord segments) that are integrated into a vertical system.

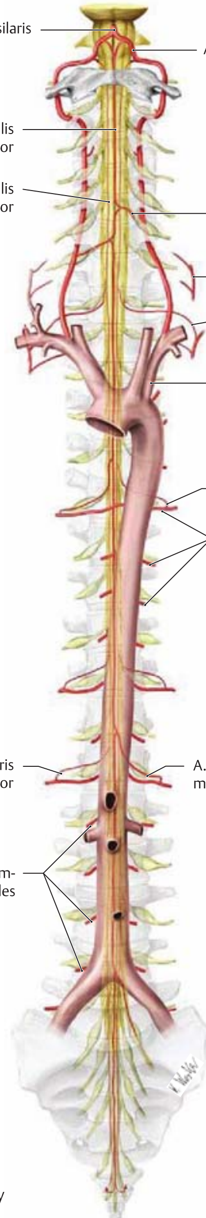
Fig. 40.11 Arteries of medulla spinalis
The unpaired anterior and paired posterior spinal arteries typically arise from the vertebral arteries. As they descend within canalis vertebralis, the spinal arteries are reinforced by anterior and posterior radicular arteries. Depending on the spinal level, these reinforcing branches may arise from the vertebral, ascending or deep cervical, posterior intercostal, lumbar, or lateral sacral arteries.



A Spinal and segmental medullary arteries.



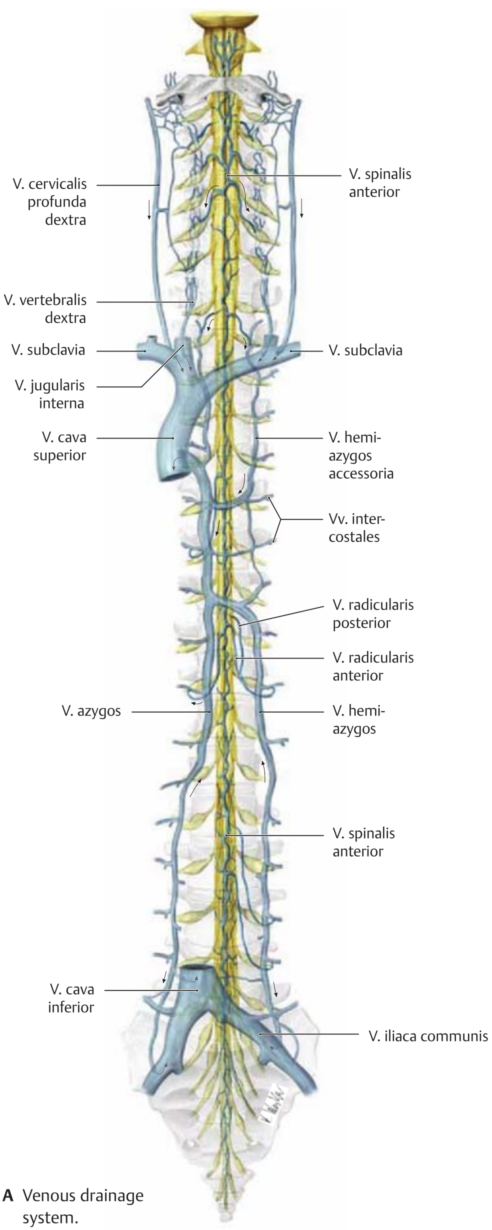
B Origins of the radicular arteries. In the thorax, the segmental medullary arteries arise from the spinal branch of the posterior intercostal arteries (see p. 34).



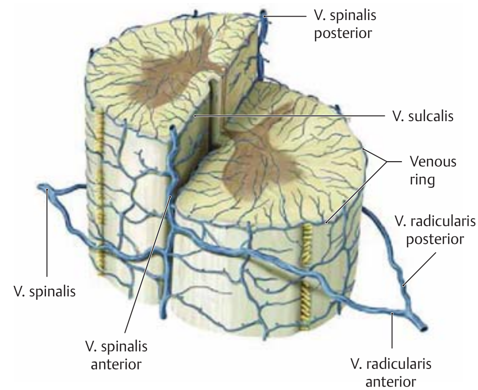
C Arterial supply system.

Fig. 40.12 **Veins of medulla spinalis**

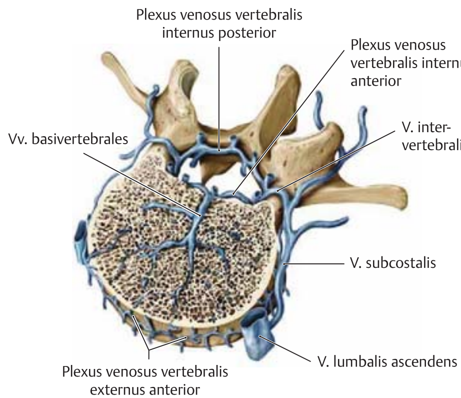
The interior of medulla spinalis drains via venous plexuses into vv. spinales anterior and posterior. The radicular and spinal veins connect the veins of the spinal cord with the plexus venosus vertebralis internus. The vv. intervertebrales and basivertebrales connect the internal and external venous plexuses, which drain into the azygos system.



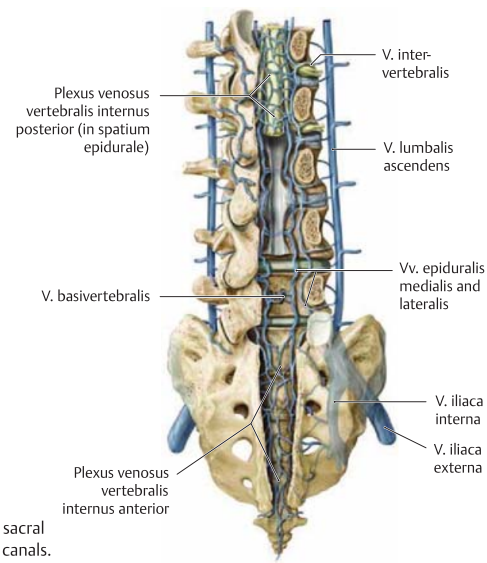
A Venous drainage system.



B Spinal and radicular veins.



C Vertebral venous plexuses.



D Veins in the sacral and lumbar canals.

Circuitry

Fig. 41.1 Divisions of the nervous system

Direction of information flow divides nerve fibers into two types: afferent (sensory) fibers, which transmit impulses toward the central nervous system (CNS), and efferent (motor) fibers, which transmit impulses away. The nervous system may also be divided into a somatic and an autonomic part. The somatic nervous system mediates interaction with the environment, whereas the autonomic (visceral) nervous system coordinates the function of the internal organs.

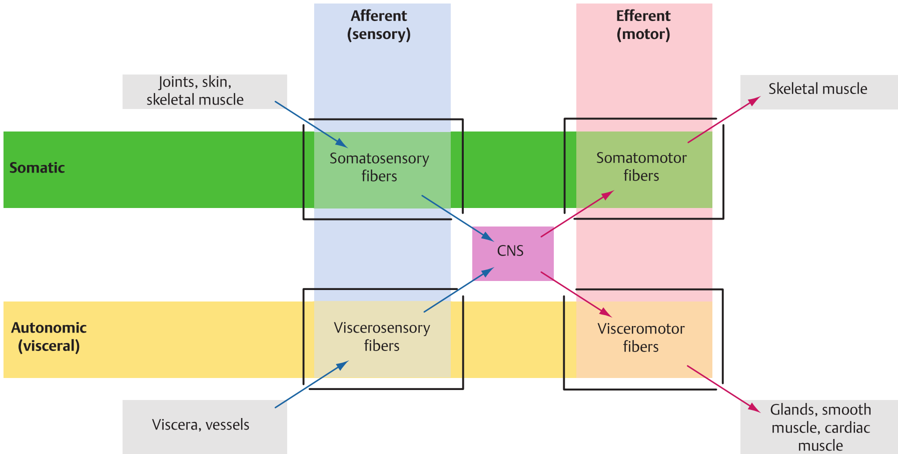


Fig. 41.2 Organization of substantia grisea

Left oblique anterosuperior view. Substantia grisea of the spinal cord is divided into three columns (horns). Afferent (blue) and efferent (red) neurons within these columns are clustered according to function.

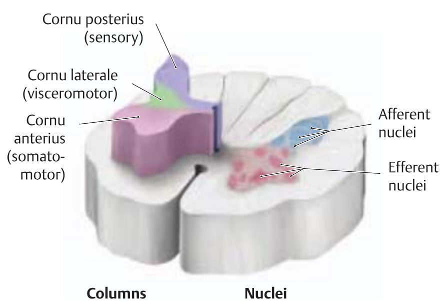


Fig. 41.3 Muscle innervation

Indicator muscles are innervated by motor neurons in the anterior horn of one spinal cord segment. Most muscles (multisegmental muscles) receive innervation from a motor column, a vertical arrangement of motor nuclei spanning several segments.

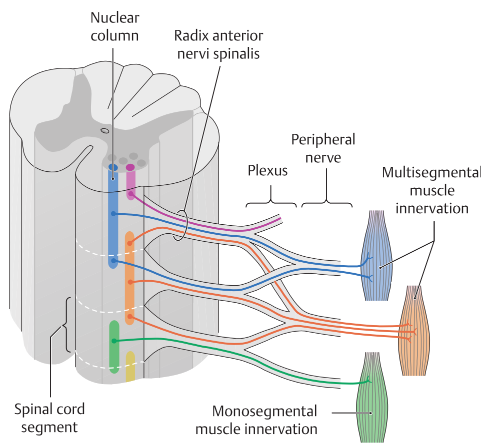
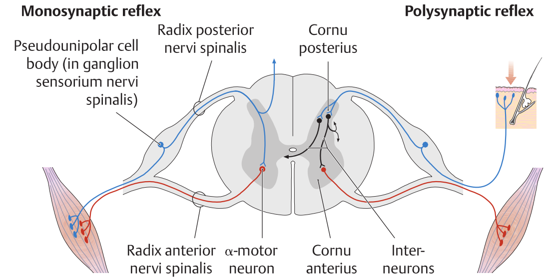
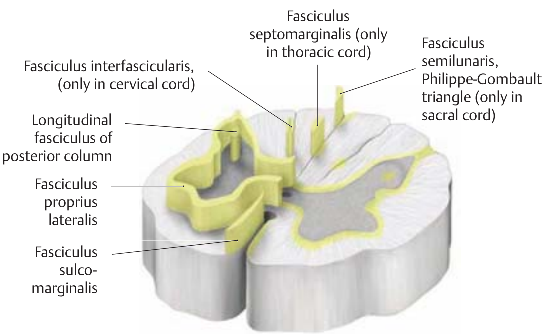


Fig. 41.4 Reflexes

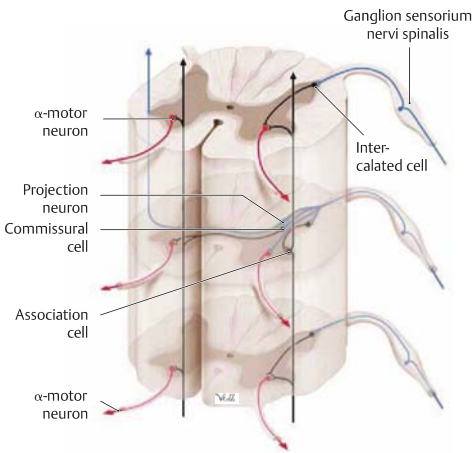
Muscular function at the unconscious (reflex) level is controlled by substantia grisea of medulla spinalis.



A Polysynaptic reflexes may be mediated by receptors inside of or remote from the muscle (i.e., skin); these receptors act via interneurons to stimulate muscle contraction.



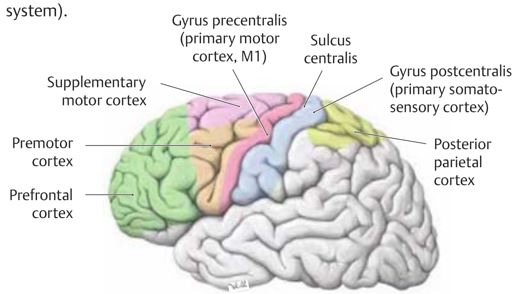
B Principal intrinsic fascicles of the spinal cord. The intrinsic fascicles are the conduction apparatus of the intrinsic circuits, allowing axons to ascend and descend to coordinate spinal reflexes for multisegmental muscles.



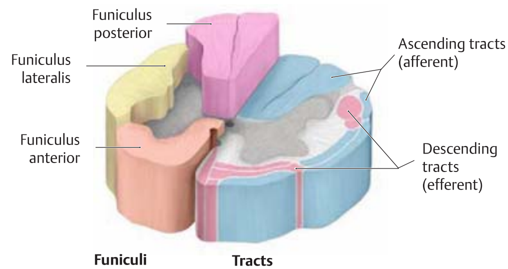
C Intrinsic circuits of the spinal cord.

Fig. 41.5 Sensory and motor systems

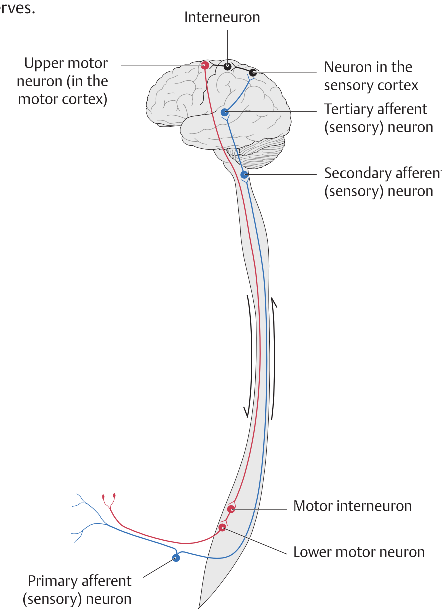
The sensory system (see p. 614) and motor system (see p. 615) are so functionally interrelated they may be described as one (sensorimotor system).



A Cortical areas of the sensorimotor system. Lateral view of the left hemisphere.



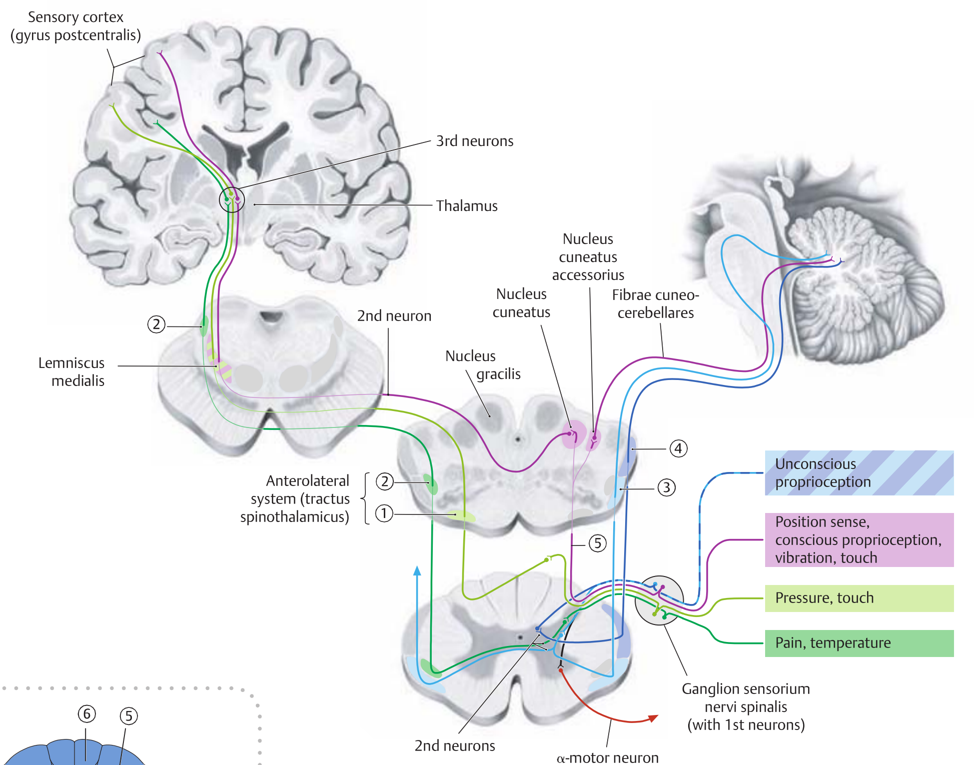
B White matter of the spinal cord. The white matter of the spinal cord contains ascending tracts (afferent, see p. 614) and descending tracts (efferent, see p. 615), which are the CNS equivalent of peripheral nerves.

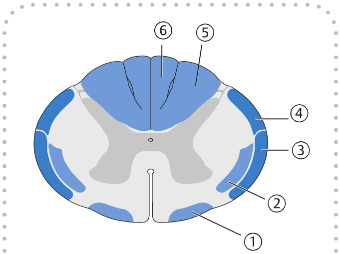


C Overview of sensorimotor integration.

Sensory & Motor Pathways

Fig. 41.6 Sensory pathways (ascending tracts)



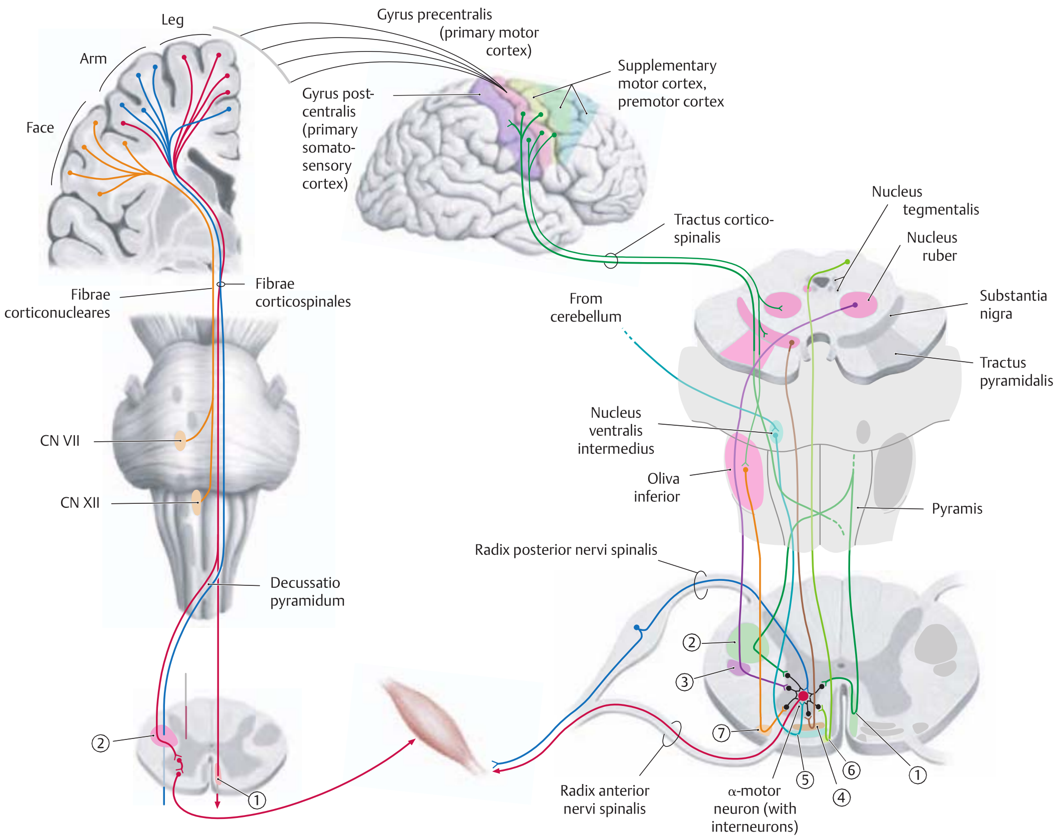


*The fasciculi cuneatus and gracilus convey information from the upper and lower limbs, respectively. At this level of medulla spinalis, only the fasciculus cuneatus is present.

Table 41.1 Ascending tracts of the spinal cord

	Tract	Location	Function		Neurons
①	Tractus spinothalamicus anterior	Funiculus anterior	Pathway for crude touch and pressure sensation		1st afferent neurons located in spinal ganglia; contain 2nd neurons and cross in commissura anterior
②	Tractus spinothalamicus lateralis	Funiculus lateralis and anterior	Pathway for pain, temperature, tickle, itch, and sexual sensation		
③	Tractus spinocerebellaris anterior	Funiculus lateralis	Pathway for unconscious coordination of motor activities (unconscious proprioception, automatic processes, e.g., jogging, riding a bike) to the cerebellum		Projection (2nd) neurons receive proprioceptive signals from 1st afferent fibers originating at the 1st neurons of spinal ganglia
④	Tractus spinocerebellaris posterior				
⑤	Fasciculus cuneatus	Funiculus posterior	Pathway for position sense (conscious proprioception) and fine cutaneous sensation (touch, vibration, fine pressure sense, two-point discrimination)	Conveys information from *upper* limb (not present below T3)	Cell bodies of 1st neuron located in spinal ganglion; pass uncrossed to the dorsal column nuclei
⑥	Fasciculus gracilis			Conveys information from *lower* limb	

Fig. 41.7 **Motor pathways (descending tracts)**



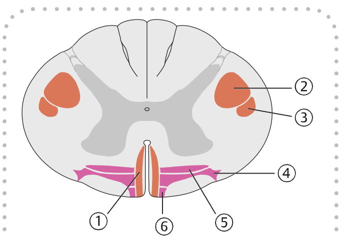


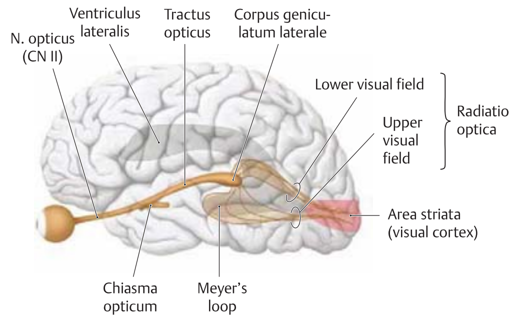
Table 41.2	**Descending tracts of the spinal cord**			
Tract			**Function**	
Pyramidal tract	①	Tractus corticospinalis anterior	Most important pathway for voluntary motor function	Originates in the motor cortex *Corticonuclear* fibers to motor nuclei of cranial nerves *Corticospinal* fibers to motor cells in anterior horn of the spinal cord *Corticoreticular* fibers to nuclei of the reticular formation
	②	Tractus corticospinalis lateralis		
Descending pathways originating in the brainstem	③	Tractus rubrospinalis	Pathway for automatic and learned motor processes (e.g., walking, running, cycling)	
	④	Tractus reticulospinalis		
	⑤	Tractus vestibulospinalis		
	⑥	Tractus tectospinalis		
	⑦	Tractus olivospinalis		

Sensory Systems (I)

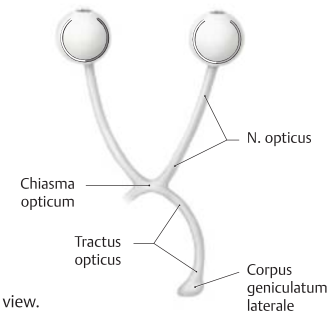
Table 41.3 Special sensory qualities (senses)

Sense	Cranial nerve		Ref.
Vision	N. opticus (CN II)		See p. 473
Balance	N. vestibulocochlearis (CN VIII)	N. vestibularis	See p. 480
Hearing		N. cochlearis	See p. 481
Taste	N. facialis (CN VII)		See p. 478
	N. glossopharyngeus (CN IX)		See p. 482
	N. vagus (CN X)		See p. 484
Smell	N. olfactorius (CN I)		See p. 472

Fig. 41.8 Visual system: Overview



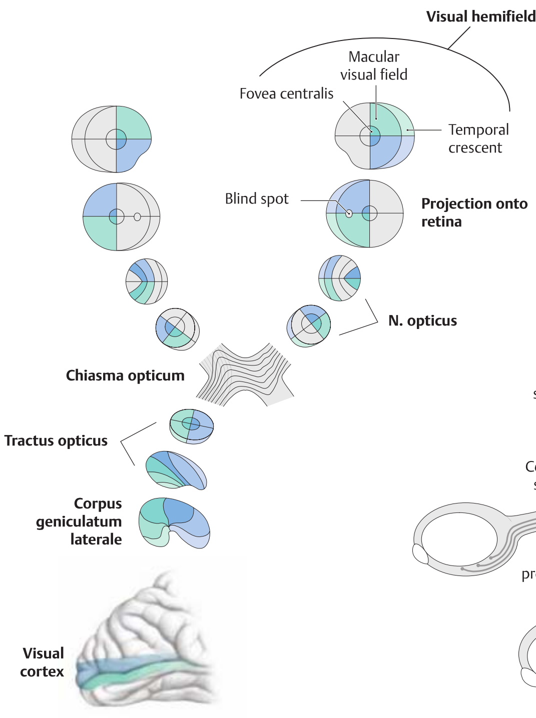
A Left lateral view.



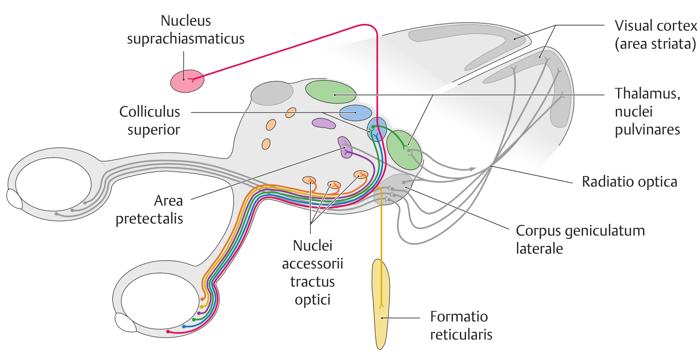
B Inferior view.

Fig. 41.9 Visual pathways

90% of optic nerve fibers terminate in corpus geniculatum laterale on neurons that project to the area striata (visual cortex). This forms the geniculate pathway, responsible for conscious visual perception. The remaining 10% travel along the medial root of the optic tract, forming the non-geniculate pathway. This pathway plays an important role in the unconscious regulation of vision-related processes and reflexes.



A Geniculate pathway. Left visual hemifield.



B Non-geniculate pathway.

Clinical

Lesions of the visual pathway

Visual field defects and lesion sites are here illustrated for the left visual pathway.

	Lesion	Visual field defect
1	Unilateral lesion of n. opticus.	Blindness in affected eye
2	Lesion of chiasma opticum	Bitemporal hemianopia ("blinders")
3	Unilateral lesion of tractus opticus	Contralateral homonymous hemianopia
4	Unilateral lesion of radiatio optica in Meyer's loop (anterior temporal lobe)	Contralateral upper quadrantanopia ("pie-in-the-sky")
5	Unilateral lesion of radiatio optica, medial part	Contralateral lower quadrantanopia
6	Lesion of lobus occipitalis	Homonymous hemianopia
7	Lesion of polus occipitalis (cortical areas)	Homonymous hemianopic central scotoma

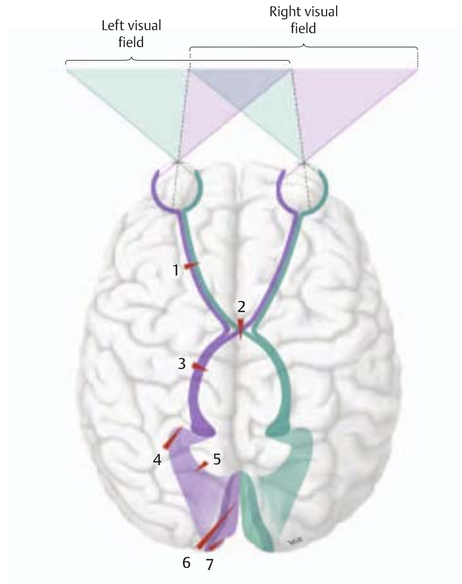
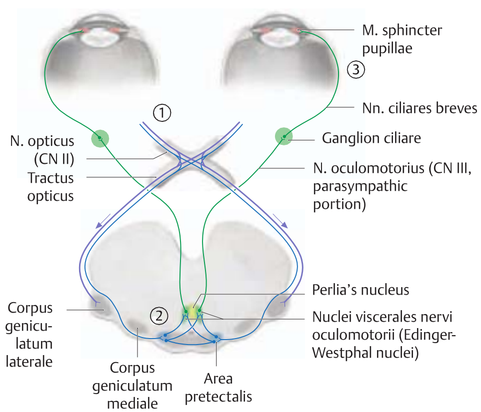
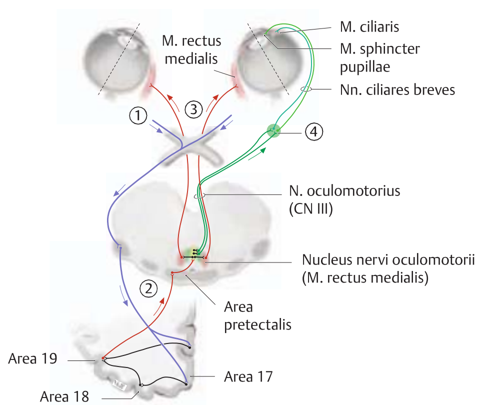


Fig. 41.10 Reflexes of the visual system

The reflexes of the visual system are mediated by the optic (afferent) and oculomotor (efferent) nerves.



A Pupillary light reflex.
① Incoming light is transmitted via the n. opticus.
② Large amounts of light are transmitted to the pretectal area, bypassing the geniculate pathway.
③ The neurons of the visceral oculomotor nucleus synapse on ganglion ciliare, which induces contraction of sphincter pupillae.



B Pathways for convergence and accommodation.
① Light is received from an approaching object.
② Information is relayed via the primary (17) and secondary (19) visual cortices to the nuclei of n. oculomotorius.
③ Convergence: Constriction of the m. rectus medialis converges the visual axes of the eyes, keeping the approaching image on the fovea centralis, the point of maximum visual acuity.
④ Accommodation: The curvature of the lens is increased via contraction of the m. ciliaris. The m. sphincter pupillae also contracts.

Sensory Systems (II)

Fig. 41.11 **Balance**
Human balance is regulated by the visual, proprioceptive, and vestibular systems. All three systems send afferent fibers to the vestibular nuclei, which then distribute them to medulla spinalis (motor support), cerebellum (fine motor function), and brainstem (oculomotor function). Proprioception ("position sense") is the perception of limb position in space. *Note:* Efferents to the thalamus and cortex control spatial sense; efferents to the hypothalamus regulate vomiting in response to vertigo.

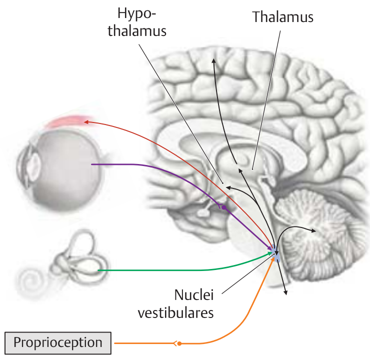


Fig. 41.13 **Vestibular system and nuclei**
The receptors of the vestibular system are located in the membranous labyrinth. The maculae of utriculus and sacculus respond to linear acceleration, whereas the semicircular duct organs in the cristae ampullares respond to angular (rotational) acceleration.

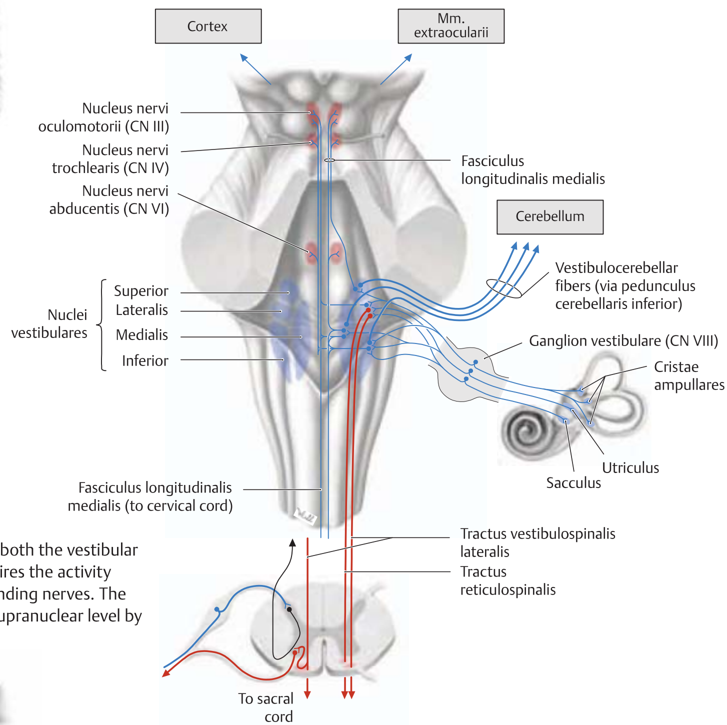
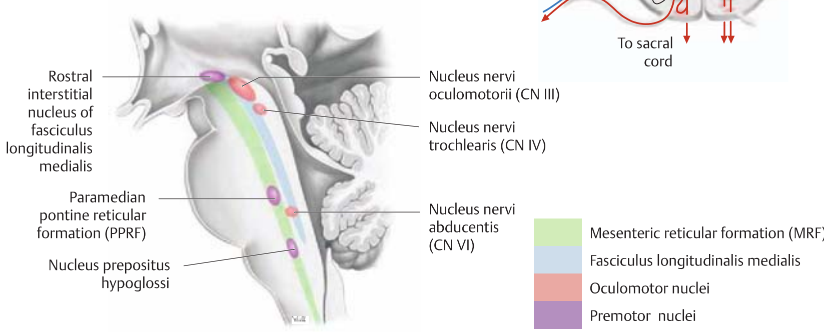


Fig. 41.12 **Oculomotor nuclei**
The oculomotor nuclei receive efferent fibers from both the vestibular and visual systems. Conjugate eye movement requires the activity of multiple extraocular muscles and their corresponding nerves. The oculomotor nuclei are therefore coordinated at a supranuclear level by premotor nuclei (purple).



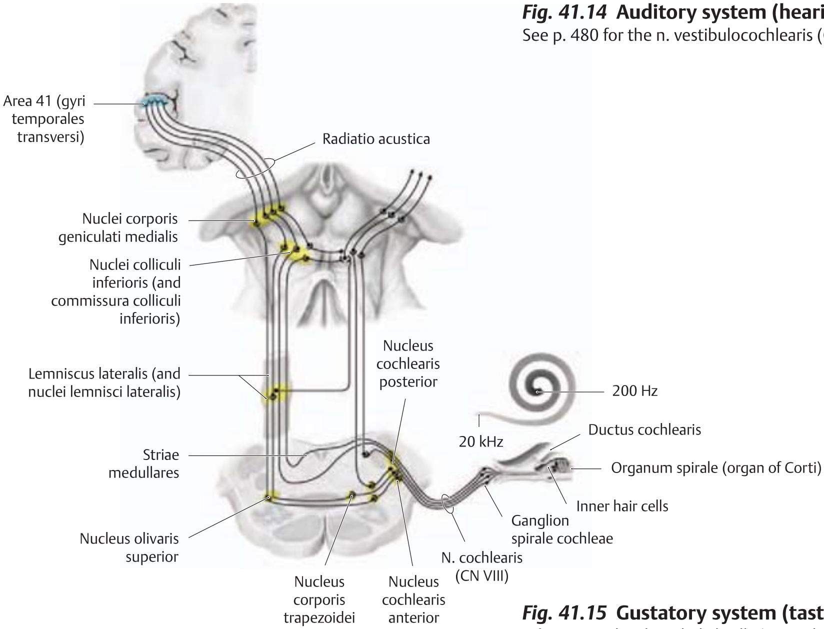
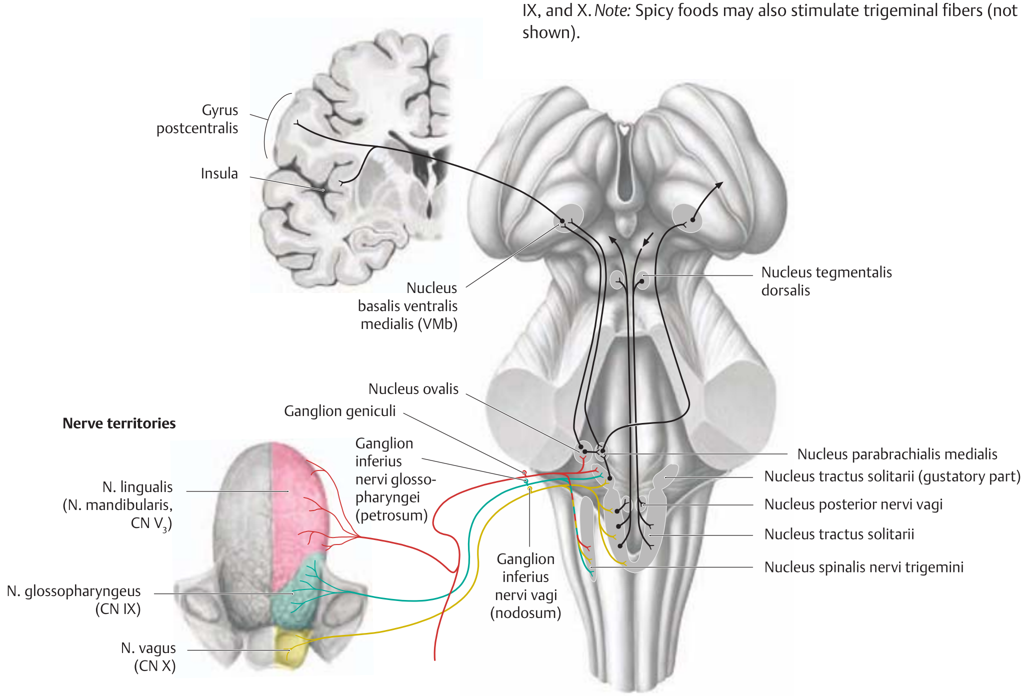


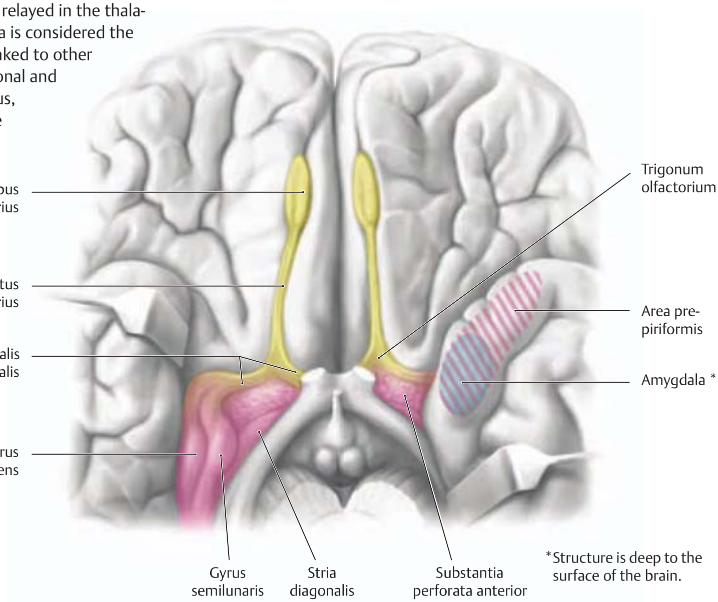
Fig. 41.14 **Auditory system (hearing)**
See p. 480 for the n. vestibulocochlearis (CN VIII).

Fig. 41.15 **Gustatory system (taste)**
When specialized epithelial cells (secondary sensory cells with no axon) in the tongue are chemically stimulated, the cell bases release glutamate, stimulating the peripheral processes of afferent cranial nerves VII, IX, and X. *Note:* Spicy foods may also stimulate trigeminal fibers (not shown).

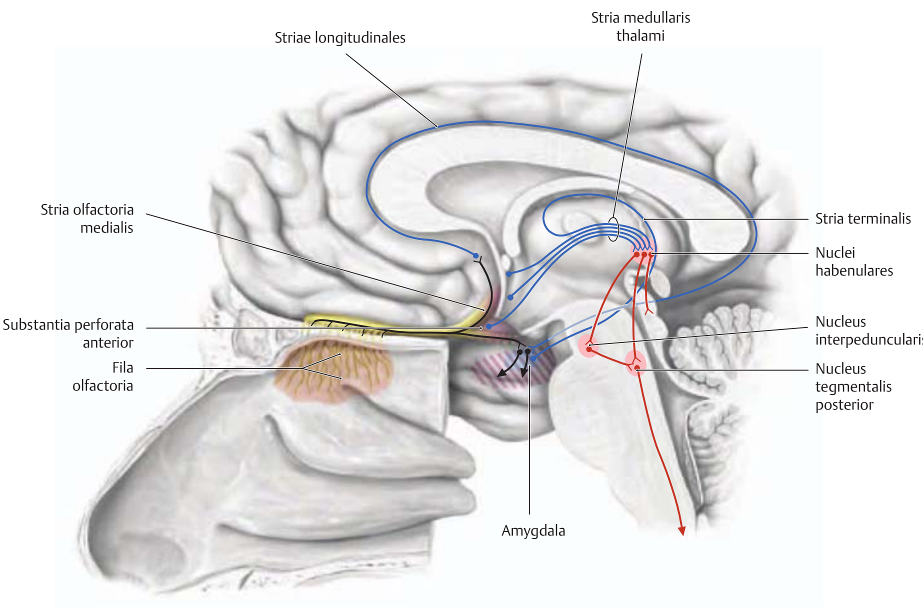


Sensory Systems (III)

***Fig. 41.16* Olfactory system (smell)**
The olfactory system is the only sensory system not relayed in the thalamus before reaching the cortex (the prepiriform area is considered the primary olfactory cortex). The olfactory system is linked to other brain areas and can therefore evoke complex emotional and behavioral responses (mediated by the hypothalamus, thalamus, and limbic system): noxious smells induce nausea; appetizing smells evoke salivation.

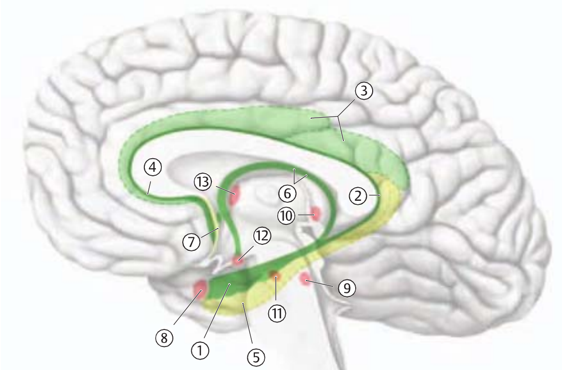


A Olfactory system, inferior view.

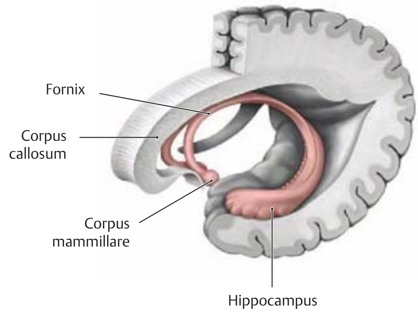


B Olfactory system with nuclei, left lateral view of midsagittal section.

The limbic system, which exchanges and integrates information between the telencephalon, diencephalon, and mesencephalon, regulates drive and affective behavior. It plays a crucial role in memory and learning.



A Midsagittal section, left lateral view.



B Hippocampus, left anterior oblique view.

Table 41.4	**Structures of the limbic system**				
Outer arc		**Inner arc***		**Subcortical nuclei**	
①	Gyrus parahippocampalis	⑤	Hippocampal formation (hippocampus, entorhinal area of gyrus parahippocampalis)	⑧	Amygdala
②	Indusium griseum	⑥	Fornix	⑨	Nuclei tegmentales dorsales
③	Area subcallosala (paraolfactory area)	⑦	Septal area (septum)	⑩	Nuclei habenulares
				⑪	Nucleus interpedunculares
④	Gyrus cinguli	Gyrus paraterminalis		⑫	Corpus mammillare
				⑬	Nuclei anteriores thalami
* The inner arc also contains the diagonal band of Broca (not shown).					

Fig. 41.17 Limbic system nuclei

This neuronal circuit (Papez circuit) establishes a connection between information stored at the conscious and unconscious level.

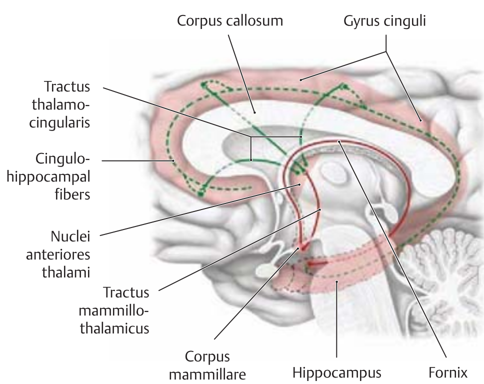
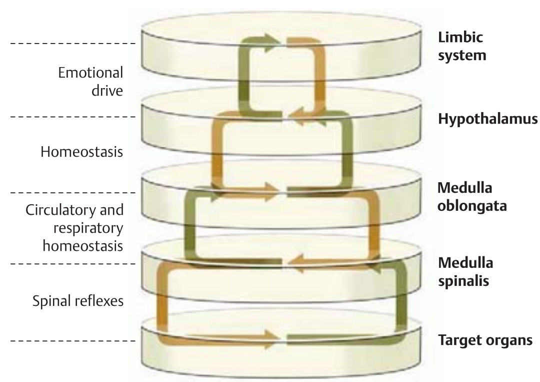


Fig. 41.18 Limbic regulation of the peripheral autonomic nervous system

The limbic system receives afferent feedback signals from its target organs. See p. 623 for the autonomic nervous system.



Autonomic Nervous System

Fig. 42.1 **Autonomic nervous system circuitry**
The autonomic nervous system innervates smooth muscle, cardiac muscle, and glands. It is divided into the sympathetic (red) and parasympathetic (blue) nervous systems, which often act in antagonistic ways to regulate blood flow, secretions, and organ function. Green: Afferent. Purple: Efferent.

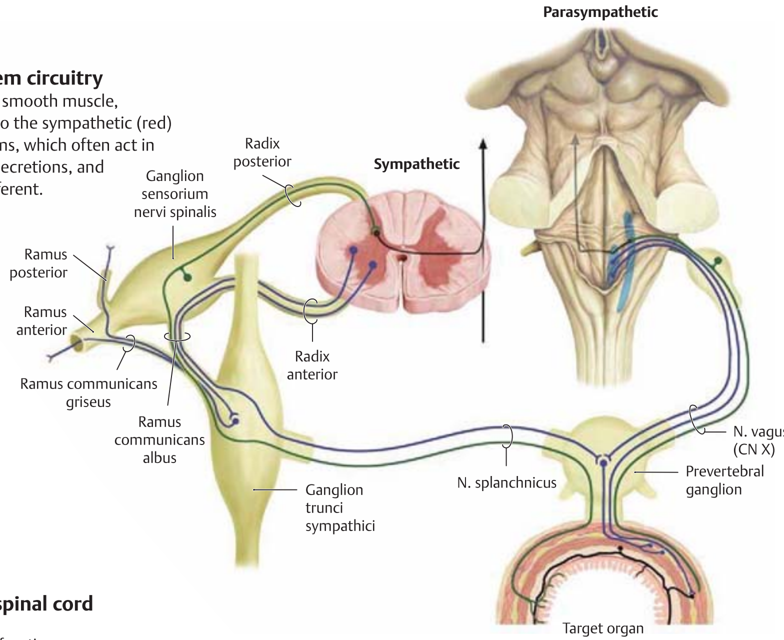


Fig. 42.2 **Autonomic tracts in the spinal cord**

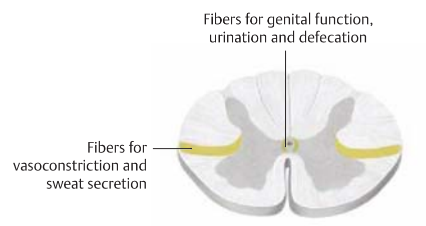


Fig. 42.3 **Regulatory effects of the autonomic neurotransmitters**

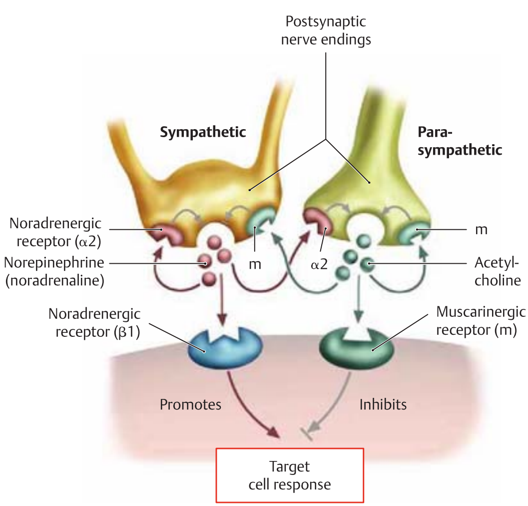


Fig. 42.4 **Blood pressure regulation**
Sympathetic fibers may release norepinephrine (noradrenaline), inducing the α1 receptor to mediate contraction of the vascular smooth muscle (thus increasing blood pressure). Circulating epinephrine (adrenaline) acts on the β2 receptors to induce vasodilation (decreasing blood pressure). *Note:* Parasympathetic fibers do not terminate on blood vessels.

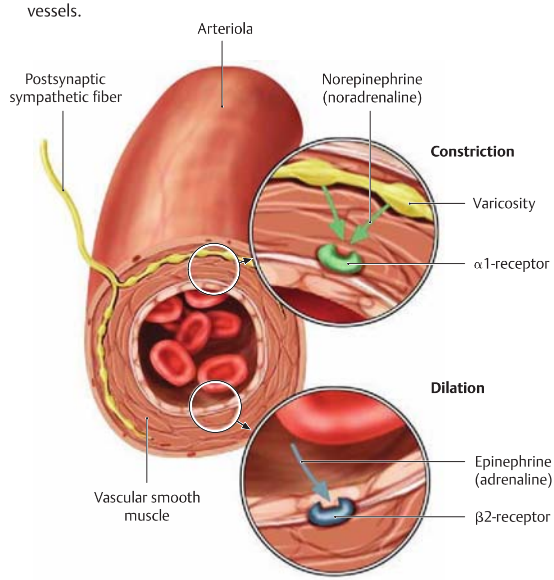
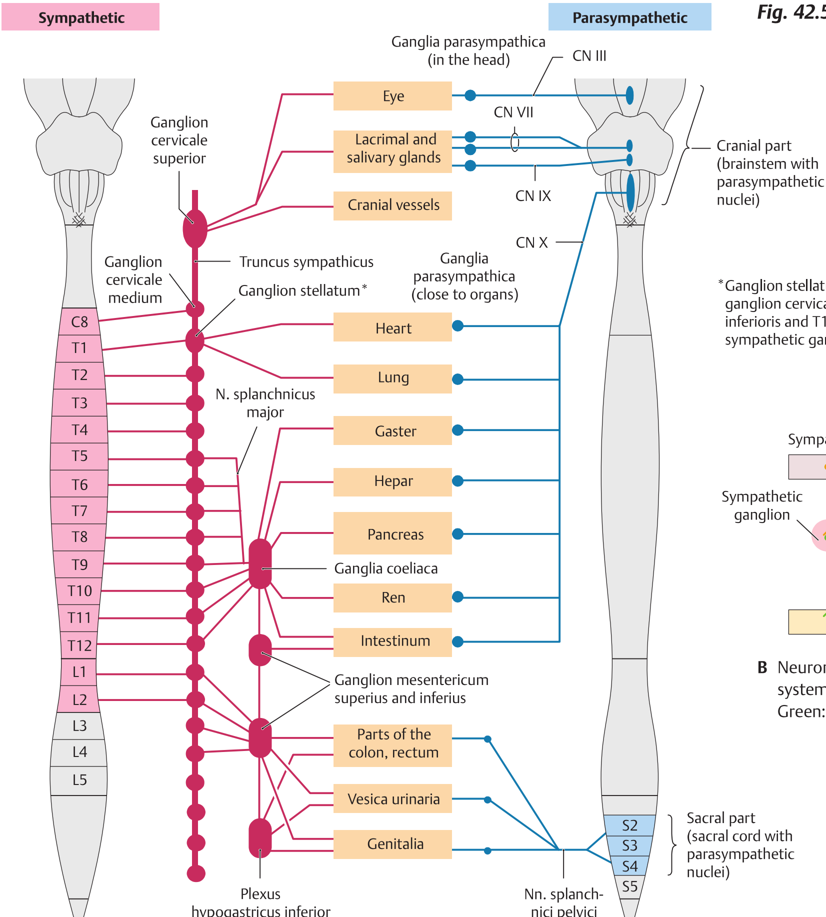
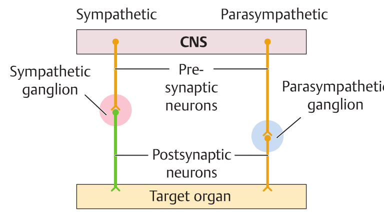


Fig. 42.5 Autonomic nervous system



A

*Ganglion stellatum = ganglion cervicale inferioris and T1 sympathetic ganglion



B Neurons of the autonomic nervous system. Orange: Cholinergic neuron. Green: Noradrenergic neuron.

Table 42.1 Effects of the sympathetic and parasympathetic nervous systems

Organ (organ system)		Sympathetic NS effect	Parasympathetic NS effect
Gastro-intestinal tract	Tunica muscularis, stratum longitudinale and stratum circulare	Decreases motility	Increases motility
	Sphincter muscles	Contraction	Relaxation
	Glandulae intestinales	Decreases secretions	Increases secretions
Capsula splenica		Contraction	
Hepar		Increases glycogenolysis/gluconeogenesis	No effect
Pancreas	Endocrine pancreas	Decreases insulin secretion	
	Exocrine pancreas	Decreases secretion	Increases secretion
Vesica urinaria	M. detrusor vesicae	Relaxation	Contraction
	Functional bladder sphincter	Contraction	
Glandula vesiculosa		Contraction (ejaculation)	No effect
Vas deferens			
Uterus		Contraction or relaxation, depending on hormonal status	
Arteries		Vasoconstriction	Vasodilation of the arteries of the penis and clitoris (erection)

NS = nervous system. See also p. 244.

Appendix

Answers to Surface Anatomy Questions

Back (pp. 40–41)

Q1: The superior boundaries of Michaelis' rhomboid run from processus spinosus of L IV to spina iliaca posterior superior. The rhomboid then follows the curve of crista iliaca to the anal cleft.

Q2: Angulus inferior scapulae is at the level of processus spinosus of T VII. Crista iliaca is at the level of processus spinosus of L IV. See p. 40 for palpable bony landmarks.

Thorax (pp. 120–121)

Q1: After careful inspection, undertake a systematic palpation of each breast. Palpate the tissue of each breast by quadrant in the following sequence: inferior lateral, inferior medial, superior medial, and superior lateral. Palpate the axilla to examine the axillary tail of breast tissue. The majority of lymph drainage from the breast is to nll. axillares. The nll. parasternales, which run along a. and v. thoracica interna, drain the medial portions of the breast. See p. 64 for the nll. axillares.

Q2: Valvae aortae and trunci pulmonales are best auscultated at the 2nd right and left intercostal spaces, respectively. Locate the 2nd intercostal spaces by finding the usually palpable angulus sterni (the junction between the manubrium and corpus of the sternum). The 2nd ribs attach to the sternum at the angulus sterni. The valva tricuspidalis (right atrioventricular valve) and valva mitralis (left atrioventricular valve) are best auscultated at the left 5th intercostal space. If the ribs are visible/palpable, the 5th rib can be found by counting up from below (the lowest rib at the midclavicular line is the 10th rib). See p. 87 for auscultation sites; see p. 120 for reference lines in the thorax.

Abdomen & Pelvis (pp. 248–249)

Q1: Use a vertical and a horizontal line through the umbilicus (at approximately the level of L IV) to divide the abdomen and pelvis into right and left upper and lower quadrants (see p. 142).

LUQ	Liver, stomach, colon transversum, small intestine, spleen, pancreas, duodenum, colon descendens, left kidney and glandula suprarenalis, left ureter.
RUQ	Liver, stomach, colon transversum, small intestine, gallbladder, pancreas, duodenum, colon ascendens, right kidney and glandula suprarenalis, right ureter.
LLQ	Small intestine, colon descendens, left ureter, urinary bladder, reproductive organs.
RLQ	Small intestine, colon ascendens (with cecum and appendix vermiform), right ureter, urinary bladder, reproductive organs.

Q2: *Direct* inguinal hernias are most common in middle-aged or older males and are believed to be caused by "wear and tear." They typically occupy the medial portion of canalis inguinalis (having exited the abdomen through the inguinal triangle). They may also exit via the superficial inguinal ring. Rarely, they enter the scrotum. *Indirect* hernias are seen in male children and young adults and are believed to have a congenital basis. They generally exit via the deep inguinal ring and thus may occupy the entire length of canalis inguinalis. They may also exit via the superficial inguinal ring, and occasionally enter the scrotum. See p. 135 for inguinal hernias.

Upper Limb (pp. 350–353)

Q1: The nn. cutanei antebrachii medialis and lateralis are both vulnerable during intravenous punctures in the fossa cubiti. The n. medianus is a direct branch from fasciculi medialis and lateralis of plexus brachialis; the lateral nerve is the cutaneous component of n. musculatocutaneus (fasciculus lateralis). See p. 339 for the cubital region.

Q2: With the elbow joint in flexion, the ulnar collateral ligament can be palpated using the olecranon, the epicondylus medialis and lateralis, and the processus coronoideus. The lig. collaterale radiale can be palpated using the epicondylus lateralis. See p. 284 for the collateral ligaments of the elbow.

Q3: In the wrist, the m. flexor carpi ulnaris tendon runs laterally to the a. and n. ulnaris until the canalis ulnaris. N. medianus is located between the palpable tendons of m. palmaris longus and m. flexor carpi radialis. A. radialis is slightly lateral to the m. flexor carpi radialis tendon. See p. 342 for the topography of the carpal region.

Q4: Tenderness at the base of the anatomic snuffbox suggests a fracture of os scaphoideum. See p. 347 for the anatomic snuffbox; see p. 299 for scaphoid fractures.

Lower Limb (pp. 450–451)

Q1: Caput femoris is located directly behind the a. femoralis. A. femoralis emerges below the midpoint of the ligamentum inguinale. See p. 436 for the inguinal region.

Q2: N. ischiadicus can be located as it exits foramen ischiadicum majus by identifying the midpoint between spina iliaca posterior superior and tuber ischiadicum. In the gluteal region (see pp. 438–439), n. ischiadicus passes just medial to the midpoint of a line connecting trochanter major of the femur and tuber ischiadicum. N. fibularis communis can be palpated on the lateral border of fossa poplitea as it courses along the medial border of the m. biceps femoris tendon (see p. 442). At the ankle, n. tibialis is located midway between the palpable medial malleolus and the calcaneal (Achilles') tendons (see p. 442).

Head & Neck (pp. 588–589)

Q1: A bolus of anesthetic injected approximately two thirds of the way up the posterior border of the m. sternocleidomastoideus would serve as a nerve block for the plexus cervicalis.

Q2: The confluence sinuum is found deep to the protuberantia occipitalis externa. See p. 608 for the sinus durae matris.

Q3: The regio cervicalis lateralis is bounded by the mm. sternocleidomastoideus and trapezius and clavicula. It contains the ramus externus of n. accessorius (CN XI) and plexus brachialis. See p. 576 for the triangles of the neck. See p. 582 for the contents of the regio cervicalis lateralis.

Q4: Trigonum caroticum is bounded by m. sternohyoideus, venter posterior of m. digastricus, and m. sternocleidomastoideus. It contains n. vagus (CN X). See p. 576 for the triangles of the neck. See p. 580 for the contents of trigonum caroticum.

Q5: Cartilago thyroidea (see p. 570) is commonly referred to as the "Adam's apple."

Index

Note: *Italicized* page numbers represent clinical applications. Tabular material is indicated by a “t” following the page number.

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